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14. ABSTRACT
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sector. While the concept of placing military transports in commercial service has advantages for the National Airlift Fleet; in reality, military transport manufacturers have garnered little success in attempting to market commercial versions of the aircraft. To determine why the lack of success, this study analyzes three aircraft that had or have civil-military potential. The first two aircraft are the Lockheed C-141 Starlifter and C-130 Hercules. Both of these aircraft are successful military transports. However, commercial success was achieved only by the latter and only after the manufacturer assumed some of the financial risk. The analysis of these two aircraft centers on the technological differences, political influences, and economic factors that affected the development of each aircraft?s commercial variant. The analysis revealed the overwhelming importance of targeting a market niche that exploits the aircraft?s technology. In this respect, economic viability of the aircraft maintains primacy. Additionally, the importance of a strong, consistent production run of the military version (or critical component such as an engine) is critical in foreshadowing success or failure of the commercial venture. After exploiting the historical evidence, this study examines a potential contemporary military transport, the McDonnell Douglas C-17 Globemaster III and its proposed commercial variant the MD-17. McDonnell Douglas?s marketing plan is compared against the current military and commercial environment to determine if conditions are favorable for the development of a contemporary civil-military transport. This thesis found that the current climate in the commercial and military sector is favorable to the fielding of a contemporary civil-military; however, development of an entirely new civil-military transport appears extremely unlikely. In sum, this study found that civil-military transports remain a viable concept, and that the Air Force can benefit by proactively supporting civil-military transport development if the aircraft appears economically viable in the commercial sector.

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EXPANDING THE NATIONAL AIRLIFT FLEET:
THE QUEST FOR A
CIVIL-MILITARY TRANSPORT

BY

TIMOTHY M. ZADALIS

A THESIS PRESENTED TO THE FACULTY OF

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The conclusions and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

Dedication

For My Father: CMSgt Robert M. Zadalis, USAF, Retired

About The Author

Major Timothy M. Zadalis was commissioned through Officer Training School, Lackland AFB, Texas, in 1984. Upon completion of undergraduate pilot training in 1985, Major Zadalis was selected to fly C-141s and assigned to the 4th Military Airlift Squadron at McChord AFB, Washington. In addition to upgrading to instructor pilot, he was selected as initial cadre for the Prime Nuclear Airlift Force and served as a Command Post Senior Controller. In 1989, Major Zadalis was reassigned to the 57th Military Airlift Squadron, Altus AFB, Oklahoma, as a "schoolhouse" instructor in the C-141. In addition to upgrading to flight examiner, Major Zadalis served as the Wing, Chief of Readiness and was selected as the Company Grade Officer of the Year, 1992. In 1993 he was reassigned to Headquarters Air Mobility Command Directorate of Personnel, Scott AFB, Illinois, where he served as the Chief of Airlift Assignments, Chief of Rated Staff Assignments, and as a Presidential Advance Agent. Major Zadalis is a s senior pilot with over 3,500 hours, a graduate of Air Command and Staff College, and a distinguished graduate from Squadron Officer School and Officer Training School.

Major Zadalis has a Bachelor of Science Degree in Biology from the University of Alaska, Fairbanks and a Master's of Art in Management from Webster University St. Louis, Missouri. Upon graduation from the School of Advanced Airpower Studies, he will be reassigned as an Assistant Operations Officer in the 4th Airlift Squadron at

McChord AFB, Washington. Major Zadalis is married to the former Carol A. Grieme of Fairbanks, Alaska and they have four children, Alysé, Bryan, Aaron, and Beth.

Acknowledgments

First, I would like to thank the entire School of Advanced Airpower Studies (SAAS) faculty. The year has been demanding and fun, and I want each of you to know I am walking away from SAAS a better officer and airpower advocate, than when I walked in.

Second, I owe special thanks to my thesis advisor and reader. This thesis began with a vague concept and an amorphous mass of data. However, over the months, with the assistance and guidance of Col Robert Owen and Lt Col Clayton Chun, a thesis emerged. Their advice, critiques, and encouragement were invaluable as I made my way through this challenging and arduous process.

Most of all, I want to thank my wife, Carol, and my children, Alysé, Bryan, Aaron and Beth, without whose support this thesis, and for that matter this year, would not have been possible. Their constant encouragement, patience, and understanding were a welcome relief on those days when "the mountain looked insurmountable."

Abstract

The term “civil-military transport” applies to a broad group of aircraft that serve in both the commercial and military sectors. This thesis focuses on one civil-military transport subgroup; namely, transports designed for the military and marketed by their manufacturers in the commercial sector. While the concept of placing military transports in commercial service has advantages for the National Airlift Fleet; in reality, military transport manufacturers have garnered little success in attempting to market commercial versions of the aircraft. To determine why the lack of success, this study analyzes three aircraft that had or have civil-military potential. The first two aircraft are the Lockheed C-141 *Starlifter* and C-130 *Hercules*. Both of these aircraft are successful military transports. However, commercial success was achieved only by the latter and only after the manufacturer assumed some of the financial risk. The analysis of these two aircraft centers on the technological differences, political influences, and economic factors that affected the development of each aircraft’s commercial variant. The analysis revealed the overwhelming importance of targeting a market niche that exploits the aircraft’s technology. In this respect, economic viability of the aircraft maintains primacy. Additionally, the importance of a strong, consistent production run of the military version (or critical component such as an engine) is critical in foreshadowing success or failure of the commercial venture. After exploiting the historical evidence, this study examines a potential contemporary military transport, the McDonnell Douglas C-17 *Globemaster III* and its proposed commercial variant the MD-17. McDonnell Douglas’s marketing plan is compared against the current military and commercial environment to determine if

conditions are favorable for the development of a contemporary civil-military transport. This thesis found that the current climate in the commercial and military sector is favorable to the fielding of a contemporary civil-military; however, development of an entirely new civil-military transport appears extremely unlikely. In sum, this study found that civil-military transports remain a viable concept, and that the Air Force can benefit by proactively supporting civil-military transport development if the aircraft appears economically viable in the commercial sector.

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Chapter 1

Introduction

> *The national defense airlift objective is to ensure that military and civil airlift resources will be able to meet defense mobilization and deployment requirements in support of U.S. defense and foreign policies. Military and commercial resources are equally important and interdependent in the fulfillment of this national objective.*
>
> —National Security Directive # 280
> National Airlift Policy, 1989

Global Reach—Global Power

The United States (US) has national interests and objectives spread throughout the world. Protecting these interests and objectives requires a strong military force capable of projecting power. The US is unique among the nations of the world in that it is the only nation capable of projecting power globally. In the initial phases of any action, it is the nation's airlift fleet that bears the burden of this task; whether it be war or humanitarian relief operations, airlift is vital. Without a credible airlift fleet that can rapidly deploy forces, the war winning potential and the deterrent value of the military is significantly weakened.

Rapid mobility is a critical component of US foreign policy. A strong airlift fleet supports the National Command Authority (NCA) in two ways. First, it ensures that our military can rapidly deploy throughout the world with significant force. This coercive

aspect of airlift is especially important as forward deployed forces redeploy to the continental US as a result of decreased tensions and budget cuts. Second, rapid mobility offers a non-coercive tool of diplomacy. Airlift operations such as humanitarian and disaster relief, and peacekeeping support influence many nations through positive, non-violent means. This often overlooked role of airlift is pivotal in promoting stability and creating goodwill towards the US. Both of these roles demand a strong and robust airlift fleet.

To maximize airlift capacity, US National Airlift Policy ties commercial air carriers and the military airlift fleet into a synergistic team--the National Airlift Fleet (NAF).[1] On one hand, the National Airlift Policy supports the commercial sector by mandating maximum use of commercial assets by the military when possible. The commercial sector contributes to the NAF through the Civil Reserve Air Fleet (CRAF) program. Under this program, commercial carriers voluntary enter into contracts with the Air Force that allow the use of their aircraft during national emergencies. [2] In exchange, CRAF participants receive priority access to government airlift contracts. On the other hand, the military sector operates missions the commercial sector is incapable of handling, whether for technological or policy reasons. Examples of military-specific missions include the airdropping of cargo and personnel, special or classified cargo movements, and operations in environments that present a measure of risk to the crew and aircraft.

Despite having a comprehensive National Airlift Policy and a robust National Airlift Fleet, the US generally has not expended the resources necessary to meet baseline military mobility requirements. Over the last 20 years, successive airlift studies such as the Congressionally Mandated Mobility Study, the Mobility Requirements Study, and the

Mobility Requirements Study Bottom-Up Review have all confirmed significant airlift shortfalls.[3] These shortfalls ebb and flow depending upon the threat. The latest change in the airlift requirements reflect the end of the Cold War and the primacy of the two major regional contingencies scenarios. However, also contributing to the airlift shortfall is the nation's move away from basing forces forward towards an expeditionary posture.

To help fill the ever changing airlift "gap" the government has attempted, over the past several decades, to expand the civil sector's ability to perform military missions. One avenue of expansion has been through a series of Presidential airlift policy statements that support the maximum use of the commercial sector and the refinement of the CRAF program. The second avenue of expansion has been through improving the technological capabilities of the commercial fleet. One aspect of this avenue has been for the government to encourage commercial carriers to purchase and operate aircraft more suited for the military requirement, with an ultimate goal of developing and producing an aircraft that can operate effectively in both sectors. These aircraft fall under the umbrella term, "civil-military transports." While the term civil-military transport technically covers any aircraft that operates in the commercial and military sector, this thesis focuses on one specific segment of civil-military transports; namely, aircraft designed specifically for the military and then also purchased by commercial carriers.

In general, civil-military transport programs designed to increase the capability and military utility of the commercial sector have garnered little success. The Lockheed C-130 has had limited success in the commercial sector; the Lockheed C-141, C-5A, and C-5B have had no success; and the McDonnell Douglas C-17 has yet to spin-off a

commercial variant. Thus, a cursory glance at the civil-military transport track record leads one to believe the concept is nearly impossible to achieve.

To date, numerous factors have limited the success of civil-military transports. The first barrier is technological in nature. The challenge of designing an aircraft with features that appeal to both sectors is daunting. In fact, the technological requirements of each sector has contributed to major differences between commercial and military transport designs. The second potential barrier is policy. Politically, a civil-military transport is attractive. However, without governmental support the concept may flounder. The third factor is economic. Generally speaking, the commercial sector is unwilling to invest capital in and operate a civil-military transport that does not provide the maximum rate of return on their investment. Yet despite these barriers, calls for the development of a civil-military transport continue.[4]

Given the potential usefulness of a civil-military transport, this study asks whether or not the technological, political, and economic factors that influenced past civil-military transports have changed in ways that may facilitate the development of a contemporary civil-military transport.

Methodology

To answer this question, this thesis begins with an examination of civil-military transport developmental theory. Chapter 2 advances the civil-military transport developmental model that identifies how civil-military transports could evolve from a simple concept to an aircraft that is capable of operating in both sectors. This model leads to an examination of the military sector's requirements. Additionally, it examines

how military requirements can influence civil-military transport development; mainly, by identifying market niches and by prescribing the conditions under which a civil-military transport must operate in order to become viable in both sectors. Furthermore, this chapter analyzes how each sector's requirements have contributed to a difference in transport aircraft design.

The third chapter reviews the developmental process of three military transports that had or have potential as a civil-military transport. The first aircraft examined is the Lockheed Corporation's C-141 and its commercial variant, the L-300. The C-141 is a highly successful military transport; however, commercially it failed to sell. The second aircraft is the Lockheed C-130 and its commercial derivative, the L-100. The C-130 represents a successful military and commercial transport. Finally, this chapter examines the McDonnell Douglas C-17 and its proposed commercial derivative, the MD-17. These three case studies will help isolate the factors that influenced the success or demise of their commercial derivative.

Chapter 4 examines current conditions to determine if significant shifts have occurred to allow the development of a contemporary civil-military transport. In particular, it examines economic and political changes in the commercial and military sector.

This thesis concludes with a summary and recommendations concerning the viability of civil-military transports.

Notes

[1]For an in-depth description of the National Airlift System see Major William G. Palmby, "Enhancement of the Civil Reserve Air Fleet, An Alternative for Bridging the Airlift Gap" Master's thesis, School of Advanced Airpower Studies, 1996, 3-12.

Notes

[2].For a listing of requirements necessary to join CRAF see Mary Chenoweth, *The Civil Reserve Air Fleet: An Example of the Use of Commercial Assets to Expand Military Capabilities During Contingencies*, RAND N-2838-AF (Santa Monica Calif.: RAND, 1990), 6-7.

[3].Each of these studies identified differing airlift requirements and shortfalls. For exact numbers see Department of Defense, *Congressional Mandated Mobility Study (U)* (Washington D.C.: Department of Defense, 1981), (Secret); Department of Defense, *Mobility Requirements Study (U)* (Washington D.C.: Department of Defense, 1992), (Secret); and Department of Defense, *Mobility Requirements Study, Bottom-Up Review (U)* (Washington D.C.: Department of Defense, 1995), (Secret).

[4]. For three examples of recent articles concerning civil-military transports see Major Shelby G Ball, Major Michael D. Cassidy, and Major Phillip A. Chansler. "The Affordable C-17: A Joint Military-Civilian Venture." Research project, Air Command and Staff College, May 1995.; Major Kent N. Gourdin, "A Joint Venture: The Civil-Military Airplane," *Defense Transportation Journal*, April 1986, 18-23.; and Paul D. Tuck, "A Uniform National Air Cargo System, Do We Need It?" *Air University Review* 33, no. 5, July-August 1982, 58-67. In addition to these articles, numerous aviation journals have run articles concerning the McDonnell Douglas C-17 and the proposed commercial variant the MD-17. For a listing of these articles see the bibliography.

Chapter 2

Civil-Military Transport Theory

Theory has five purposes: to define; to categorize; to explain; to connect; and, ideally, to anticipate.

—Dr. Harold R. Winton
Airpower History, 1992

Moving cargo and passengers is the core mission of both the military airlift and commercial air transportation sectors of the National Airlift Fleet. While this broad statement accurately describes the general function of each sector, it ignores the specific mission differences between them. These differences influence the composition of each sector's fleet and aircraft design, and affect the viability of civil-military transports. In fact, mission differences and their underlying economic underpinnings have encouraged the development of two fleets equipped with distinct aircraft. This dichotomy has helped to make conceptualizing and developing a civil-military transport difficult in theory and practice.

By definition, a civil-military transport is an aircraft that operates in and meets the needs of both sectors. In theory, civil-military transports can be developed via three paths. First, an aircraft designed for the commercial sector can enter service in the military sector. Second, a military aircraft design competes and succeeds in the commercial sector. Third, industry and government may develop jointly an aircraft that

meets the needs of both sectors. While there are many examples of commercial aircraft entering service in the military, the reverse is uncommon. An even more difficult and heretofore unachieved path is joint commercial and military development of a civil-military transport beginning from the initial aircraft concept through aircraft production.

This chapter establishes a theoretical model that explains the developmental paths of civil-military transports, whether it is a military aircraft operating in the commercial sector, a commercial aircraft serving in the military fleet, or a jointly developed civil-military transport. This chapter further expands upon the proposed developmental model by introducing a second model that outlines how a sector's airlift requirements influence a civil-military transport's developmental path. Together, these two models show the civil-military transport developmental process and the key variables that influence its development. In discussing the theoretical models, this chapter also explores the general differences in commercial and military aircraft design.

Civil-Military Transport Developmental Path Models

Aircraft go through a series of developmental phases prior to entering service. These phases are concept development, research, prototype development, and production. While these steps are a simplification of a very complex process, they represent basic milestones in an aircraft procurement process. “Concept development” is the initial phase where the basic requirements for the aircraft are defined. When refined, the concept then enters a “research” phase to test the viability of the concept. In this phase the focus is to determine if the concept meets the requirements of the sponsoring sector and the intended customers. The next major step is the “development” of prototypes that

prove the viability of the concept. These are flying aircraft used for testing and certification. The final phase is “production.” In this phase, aircraft are produced and enter service in the sector sponsoring or targeted by the initial concept.

The initial transport aircraft concept can target the requirements of the military, commercial, or both sectors. This requires an actual or potential need in a particular sector that drives the developmental process. The sector that sponsors the aircraft development may require a new aircraft to replace an aging aircraft, a more efficient aircraft that enhances profitability, or a new aircraft with differing characteristic designed to fill a void in the sector's airlift requirements. Thus, the initial concept is “pulled” through the four step process by a requirement in either or both sectors.[5]

If the commercial and military sectors are to jointly sponsor the development of a civil-military transport, there must be an initial concept “pull” from both sectors (see figure 1).[6] In this situation the military and commercial sectors recognize the value of the aircraft and cooperate throughout the entire developmental process (from concept to production). The end result is an aircraft capable of operating in both sectors. While this example represents a desirable developmental process, civil-military transports rarely develop this way.

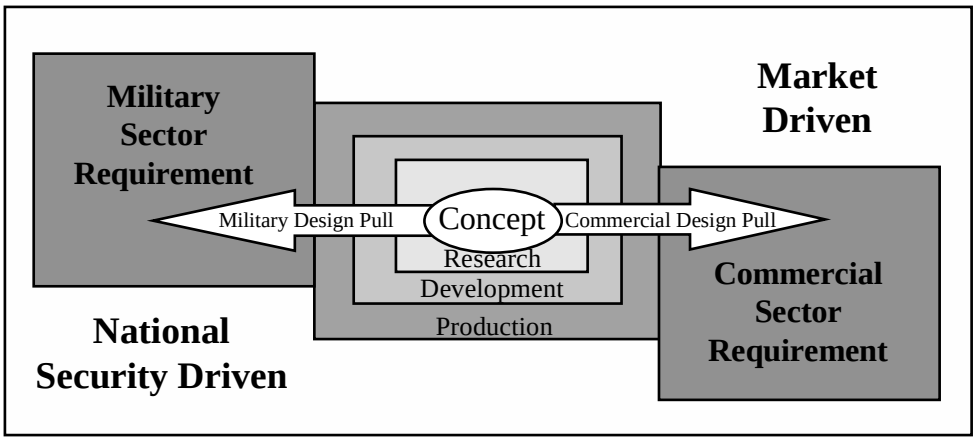

Figure 1. Joint Commercial and Military "Pull"

Often an aircraft designed for the commercial sector has utility in the military fleet. These aircraft are initially developed to fill a commercial sector need; however, somewhere during the developmental process the military takes an interest in the airframe. There are many examples of modified commercial aircraft in use in the military sector. These include the Boeing 707 as the KC-135, the DC-10 as the KC-10, and the Boeing 747 as the E-4A. When this occurs, the military finds more utility in the commercial design and takes an active interest in developing a military variant of the aircraft, rather than pursuing a military-specific concept. This results in a "military pull" on a commercial design (see figure 2). It is important to note that the operational mission these aircraft perform is not dependent upon airframe design. The commercial derivative serves as a utility platform that facilitates the mission. On the other hand, military-designed transports are dependent on airframe design since the missions they perform require specific operational characteristics.

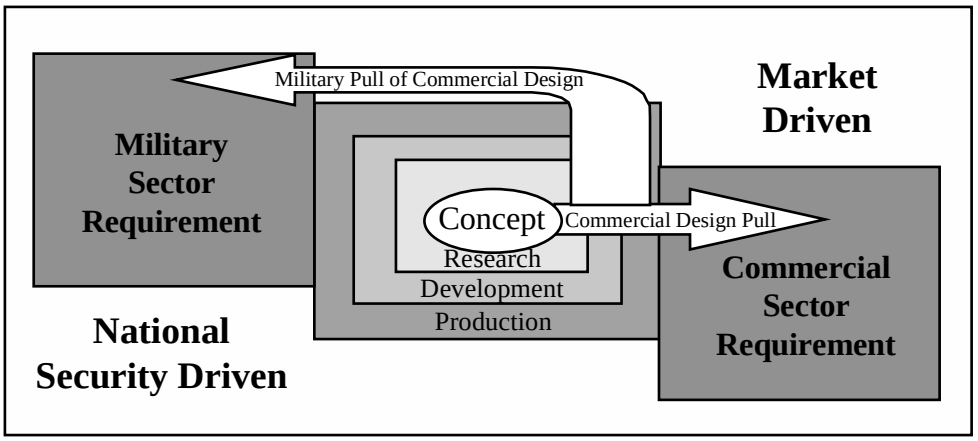

Figure 2. "Military Pull" On A Commercial Design

The final civil-military developmental path is a "commercial pull" on a military design concept. Figure 3 represents an aircraft concept developed for military use. However, there exists the potential for a civil version of the transport if the commercial sector sees an economic gain by procuring the aircraft. As in the previous example, the commercial sector takes an active interest in the development of a commercial variant.

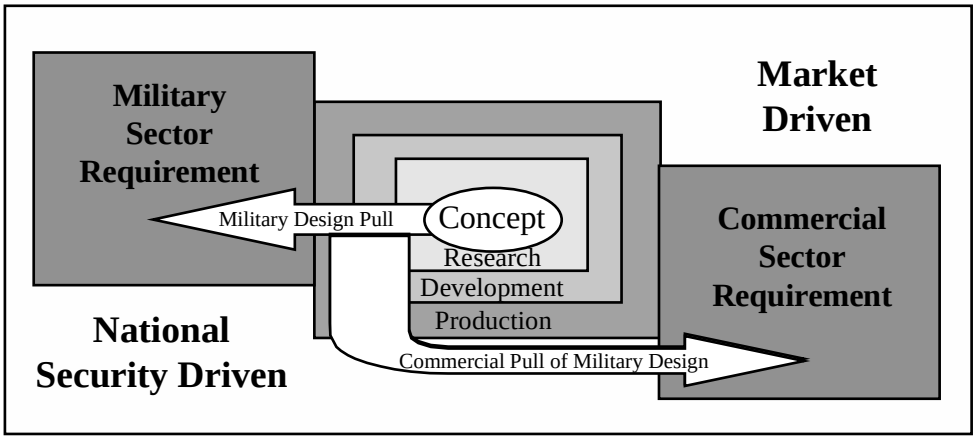

Figure 3. "Commercial Pull" On A Military Design

The "commercial pull" path (the subject of this thesis) has produced few civil-military transports. Military transports such as the Lockheed C-141 (and its commercial derivative the L-300), C-5 (and its commercial derivative the L-500), and the McDonnell

Douglas C-17 (and its commercial derivative the MD-17) have not transitioned into the commercial sector. In fact, the only US military transport that can claim success as a civil-military transport is the Lockheed C-130 and its commercial derivative the L-100.

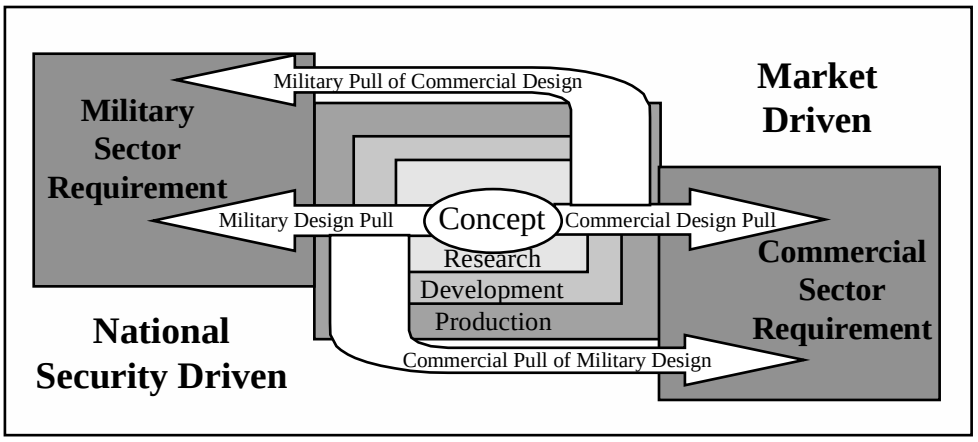

Figure 4. Civil-Military Transport Development Paths

Figure 4 combines all the potential paths for a civil-military transport. Each aircraft begins with a concept that has either or both a commercial and military pull. While this model explains the developmental paths of a civil-military transport, it does not explain the forces that drive commercial interest in a military transport or vice versa. To determine these forces, it is necessary to examine the requirements of both sectors that serve as the catalyst for a commercial or military pull.

Influences on the Civil-Military Development Models

The commercial and military sectors have specific operational and/or economic requirements that dictate an aircraft's developmental path, characteristics, and influence the aircraft's viability as a civil-military transport. Each sector optimizes its airlift fleet to meet requirements distinct from the other sector. These requirements serve as a catalyst

for the development of aircraft for that sector. By definition, a civil-military transport must satisfy an operational requirement in each sector. This can imply a parallel requirement between the commercial and military sector. This type of "parallel need" facilitates development of a civil-military transport if an optimized aircraft design is available for specific requirement. An examination of the relationship between sector requirements and the developmental process design "pull" requires the introduction of a second model that highlights each sector's requirements. Since this thesis focuses on civil-military transports based on military design characteristics (i.e., the "Military Design Pull" and a "Commercial Pull of Military Design" of figure 3) the military requirement will serve as a foundation for the next model.

In 1995, Lt Col Robert C. Owen developed a model that shows the relationship between the commercial sector and military airlift operational requirements.[7] His model described the military requirement as a spectrum of requirements and identified the operational relationship between the military and the commercial sector. The model used two main variable, policy and technology, to delineate the operational boundaries between the two sectors.

Policy is a broad term that encompasses many sub-variables. First, it includes governmental regulations and policies. For example, government regulations include Federal Aviation Administration (FAA) aircraft certification requirements. These requirements dictate mandatory capabilities and features on commercial aircraft operating in the commercial sector. The State Department also dictates policy by limiting what military technologies can enter the commercial sector. If the State Department deems a specific airlift technology sensitive, an aircraft manufacturer cannot sell the aircraft

commercially. Other governmental regulations identify what missions the military must operate regardless of the technological capability in the commercial fleet and what requirements are commercial eligible.

A second variable of policy is the operating rules and regulations of the commercial carrier. Commercial carriers implement their corporate strategy through a policy that determines what they will and will not do. A critical component of corporate policy is economics. If a significant economic incentive exists, a commercial carrier may accept an additional portion of the requirement and make the necessary investment in new assets that can accomplish the mission.

Commercial aircraft technology is the second variable that influences what portions of the military requirement the commercial sector can meet. Certain types of cargo may be within the policy guidelines for a commercial carrier; however, the commercial sector may lack the technology to handle the cargo. A prime example is outsize cargo. Within the military, there exists a portion of the outsize cargo requirement that policy dictates whether it is commercially compatible.[8] However, no US flag carrier has outsize cargo capability. Thus, the military operates these missions.

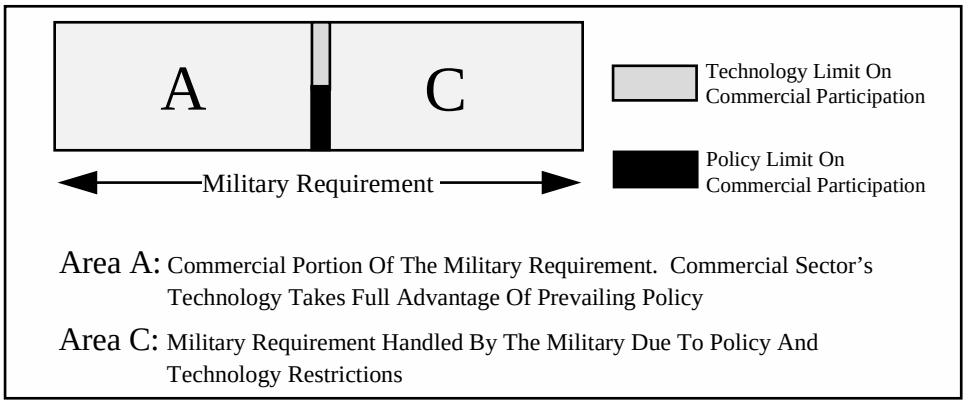

Figure 5. Case I: Technology is Optimized for Prevailing Policy

The influence of these two variables on the commercial segment's share of the military requirement can be graphically represented with three basic cases. The first case is where the policy restrictions match the technological capability of the commercial fleet (see figure 5). This situation divides the military requirement into two segments. Area "A" is the portion of the military requirement handled by the commercial sector. Area "C" is the portion of the requirement handled by the organic military airlift fleet. This case assumes a technologically optimized commercial fleet that can take full advantage of the opportunities allowed by prevailing policy. This represents an ideal situation, but in reality it is only a transition point between the other two cases.

The second case is when policy is more restrictive than the technology available (see figure 6). In this case the commercial fleet is capable of handling more of the military requirement than policy allows. The gap between area A and C (area "B") represents a portion of the requirement that the military must accomplish since policy inhibits the contracting of these missions to the commercial sector. In this situation a civil-military transport is viable in area A only if it can operate more efficiently than the aircraft currently handling the requirement (i.e., a higher profit margin).

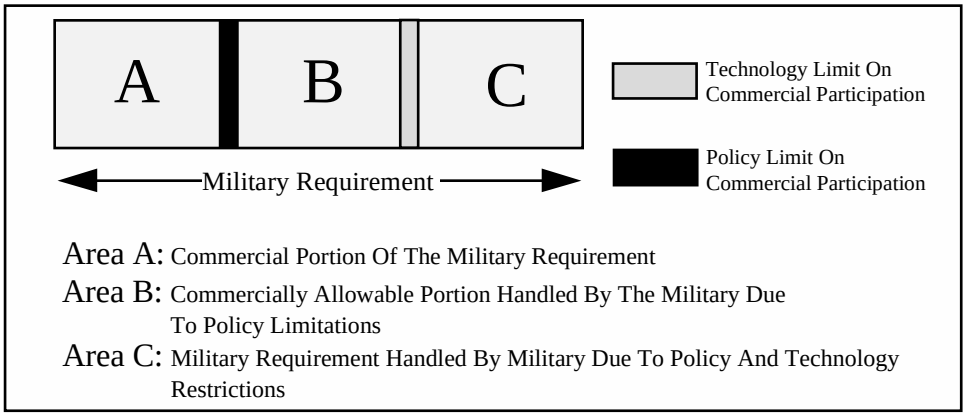

Figure 6. Case II: Policy Is More Restrictive

The third case is when policy is less restrictive than technology (see figure 7). In this situation, area B is the gap between what policy allows and what technology accommodates. Military aircraft operate in this gap because a commercial alternative capable of moving the requirement does not exist. In this situation there is potential for the fielding of a new aircraft with the features that allow it to assume this portion of the market.

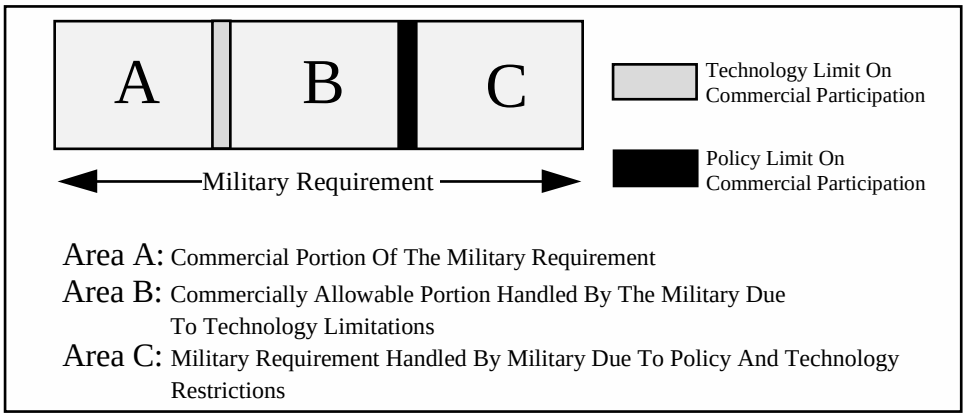

Figure 7. Case III: Technology Is More Restrictive

Cases I and II provide little in the way of justifying a civil-military transport; however, Case III provides an exception. By definition, this case identifies a gap between technology and policy with technology being more restrictive. If technology available in

military transports can fill this gap and the commercial sector desires the new technology (i.e., the "Commercial Pull on a Military Design" identified in figure 4), then this would support the development of a civil-military transport. To further analyze this theoretical case it is necessary to expand the Owen Model by adding the commercial requirement.

This new model takes into account the commercial role of a civil-military transport. The expanded model shown in figure 8 recognizes that the commercial requirement is greater than the military requirement. Again, area A represents all military requirements the commercial fleet can handle, but in reality area A is a subset of the commercial requirement, area "A_1." For a civil-military transport to compete in this region it must offer a more efficient airframe to commercial operators.

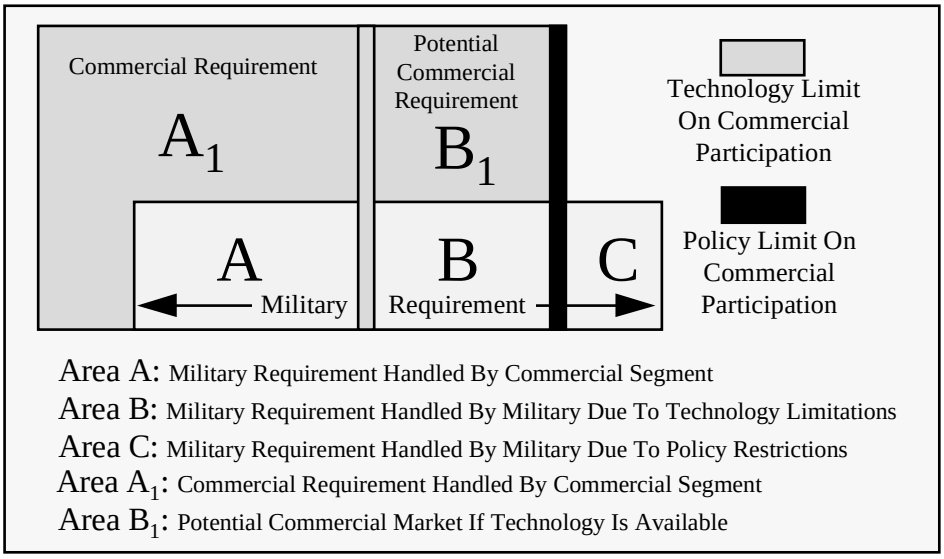

Figure 8. The Commercial and Military Requirement

In all cases, area B of the Owen Model identifies a region where there is a known military requirement; however, the commercial sector is unable to meet the need. In theory, there may be a commercial requirement (area "B_1") that parallels a military

requirement (area B). However, the commercial sector lacks the airframe to exploit the potential market (area B_1). Thus, the potential requirement in the commercial sector goes unfilled. A prime example of this niche is the outsize cargo market.

Prior to the Ukrainian built Antonov An-124 entering commercial service there was no outsize capacity in the commercial sector. On rare occasions the military moved commercial outsize cargo. Thus, there was a market in the commercial sector that needed a technology (An-124) to exploit it. Potentially, there could exist other niche markets in area B_1, the trick is to identify that market and determine if policy will allow for investment in that new technology. Area C represents requirements that are the sole domain of the military, therefore, by definition, no commercial equivalent exists.

The modified Owen model shows that a civil-military transport has two avenues into the commercial sector. First, it can undercut the competition in area A_1. If a civil-military transport can offer a more efficient airframe to the commercial carriers, they will adopt it as a means of enhancing profitability. Second, a civil-military transport can enter the commercial sector by offering a technology that opens a new market. If the potential markets in area B_1 offer a chance of increasing a company's profit margin, it will likely enter that market. The only qualifier is that policy must allow access to enough of the market to overcome the risk associated with the move. Both of these can facilitate a "Commercial Pull on a Military Design" or a "Joint Design Pull" identified in the developmental model (see figure 4).

To date, civil-military transports have had little success in penetrating area A_1 and B_1. This has helped encourage major aircraft design differences between the sectors.

Additionally, the differences in designs can pose serious challenges to the marketing of a civil-military transport that target area A_1 and B_1. Therefore, before analyzing particular civil-military transports, it is necessary to identify the differences between military and commercial cargo aircraft.

Sector Requirements Influence Aircraft Design

The commercial and military sector's requirements influence an airframe's design and characteristics. For example, military transports operate in both the strategic and tactical environments. This requires extremely flexible airframes that are capable of conducting intercontinental flight, performing airdrop missions, carrying all categories of cargo,[9] and operating in austere environments with minimal infrastructure support. These capabilities increase military aircraft throughput in all their operating environments.[10] The demand for increased throughput is at the expense of cost effectiveness and gross productivity. Conversely, the commercial sector is in the business of making money, and therefore, opts for aircraft that enhance profitability. The commercial sector concentrates on making a low initial investment to field transports that yield the most efficient movement of cargo or passengers at the lowest possible cost per cargo or passenger ton-mile.[11] In essence, economics and market requirements drive the commercial sector's aircraft needs.

The design differences between a commercial and military cargo aircraft appear obvious when compared side-by-side. The most apparent difference is the location of the wing on the fuselage. Aircraft designed specifically for the military cargo mission all have a wing that sits atop the fuselage. This places the fuselage closer to the ground

thereby lowering the height of the cargo deck. This allows truckbed height loading and limits the amount of material handling equipment (MHE) required. These characteristics facilitate operations in austere environments. A second noticeable feature is the location of the cargo doors. Military cargo aircraft have cargo loading doors located on the back of the aircraft (and the front as in the case of the C-5A/B). This allows the straight-in loading, off-loading, and airdropping of cargo. The majority of commercial cargo aircraft have side mounted cargo doors. This often requires the turning of cargo as it enters the fuselage; and limits the length and size of any individual cargo piece.

The combination of a high-wing design and rear cargo doors greatly improves the throughput capabilities of military cargo aircraft when compared to their commercial counterparts. These features allow military transports to achieve faster loading and unloading rates during ground operations, even with minimal MHE support. Additionally, military aircraft can lower the loading ramp to the ground to allow drive-on and drive-off operations. It is the combination of these factors that allow military transports to operate in relatively austere locations as compared to their commercial counterpart.

Placing the wing on the top of the fuselage is not without its drawbacks. First, this feature adds weight to the aircraft. The center support "ribs" must support and transfer the wing and engine weight through the fuselage to the landing gear. This requires stronger and heavier ribs further adding weight to the aircraft and results in decreased fuel economy. However, the empennage design of military strategic airlifters somewhat compensates for the increased weight. Aircraft such as the C-141, C-5, and C-17 all have "T-tail" configurations. This configuration places the horizontal stabilizer above the

turbulence created by the aircraft's wing and fuselage. This allows a reduction in the amount of structural bracing. In a C-141, the weight reduction is approximately 2,000 to 3,000 pounds.[12] Yet, despite this weight reduction, high-wing aircraft have significant design penalties that make them unattractive to a cost-conscious commercial sector.

A second drawback of the high-wing design is the location of the landing gear. Low-wing aircraft have their landing gear and storage wells integrated into the wing root and fuselage. Due to their design, a high-wing aircraft's landing gear is placed in pods that are external to the aircraft's fuselage. This prevents the landing gear from interfering with the cargo compartment. However, gear pods interfere with airflow and create drag. This further reduces the fuel efficiency of the aircraft.

Wing sweep is another difference between commercial cargo aircraft and their military counterparts. This difference may not be apparent to the casual observer. Military aircraft have a moderately swept wing of approximately 25 degrees, whereas the commercial sector fields a wing with greater sweep. The moderate sweep of military aircraft has several benefits. First, military aircraft require less runway for takeoffs and landings. A moderately swept wing allows the aircraft to achieve a lower takeoff and approach speed which reduces runway requirements. Second, a moderate sweep allows military aircraft to achieve lower speeds inflight. This facilitates the airdrop mission. However, a moderate wing sweep also lowers the aircraft's cruising speed. Commercial aircraft with a high sweep can obtain higher cruising speeds at altitude. This results in shorter flight times and translates into reduced operating costs.

The drive for efficiency and cost effectiveness contributes to a commercial cargo fleet that mirrors passenger aircraft design. Basing commercial cargo aircraft on proven

passenger aircraft designs makes new aircraft cheaper to purchase since they are part of a larger production run (i.e., the cost per aircraft falls with each additional unit produced). Also, contributing to the trend is the secondary market of used passenger aircraft. A firm can convert used passenger aircraft to a freighter at a much lower cost than purchasing a new aircraft. In sum, basing the commercial cargo fleet on passenger aircraft has several advantages for the commercial sector. These aircraft are faster, often less expensive, and more fuel efficient in cost per ton-mile and passenger ton-mile than their military counterparts. This reduces the overall operating costs for commercial cargo carriers. For a civil-military transport to successfully operate in the commercial sector, the economic penalties of the airframe's drag and lack of speed must be compensated by the aircraft's other attributes.

Summary

The concept of a civil-military transport is an appealing theory. The potential benefits of a common aircraft are a siren's call to many in the commercial sector and the military. However, in reality, the ability to produce a civil-military transport from a military design has proven exceedingly difficult. Additionally, the divergence in aircraft designs has further complicated and hindered attempts. The potential for a common airframe based on a military design exists; however, numerous factors can influence the development of civil-military transports. To identify the factors that could potentially influence a civil-military transport's development process, it is necessary to investigate past attempts to produce civil-military transports based on military designs.

Notes

[5].This process could also be as a result of a manufacture's "push." If an aircraft

manufacturer sees a need in either sector they may be willing to assume the developmental risk hoping the targeted sector will embrace the design. However, eventually the manufacturer‘s design “push” has to be accepted by the targeted sector, resulting in a “pull.”

[6].This figure separates the military and commercial lines since there will be minor differences between aircraft due to military and FAA certification requirements.

[7].Lt Col Robert C. Owen, “The Airlift System, A Primer,” *Airpower Journal*, Fall 1995, 16-29.

[8].A review of FY 95 C-5 missions revealed that between 170 and 200 outsize missions were commercial eligible. See McDonnell Douglas Corporation. *Selections From The MD-17 Business Plan*. GP-970137 3-97 (Long Beach Calif.: McDonnell Douglas Corporation, 1997), 3-9.

[9].The Air Mobility Command classifies all cargo into one of five categories. They are:

1. Bulk: “General cargo, typically pre-loaded on 463L pallets (104” by 84”) or containers and transportable by common aircraft.”

2. Oversize: “Cargo exceeding the usable dimension of a 463L pallet loaded to the design height of 96” but is equal to or less than 1,090” in length, 117” in width, and 105” in height. This cargo is transportable on the C-5, C-17, C-141, C-130, and KC-10.”

3. Outsize: “Cargo which exceeds the dimension of oversize and requires the use of a C-5 or C-17.”

4. Rolling Stock: “Equipment that can be driven or rolled directly into the cargo compartment.”

5. Special: “Items requiring specialized preparation and handling procedures, such as space satellites or nuclear weapons.” See Air Mobility Command, *1997 Air Mobility Master Plan* (Scott AFB, Ill.: HQ AMC/XP, 1996), 11-12.

[10].Throughput/Day = Payload x Maximum on Ground x Aircraft Serviced/Day. See Terry S. Sanford, *Strategic Airlift: Military Versus Commercial Airlift*, CRS Report for Congress 94-455F, (Washington D.C.: Congressional Research Service/Library of Congress, 25 May 1994), CRS-2.

[11].Cargo ton-mile and passenger ton-mile are two measures used to determine the relative efficiency of passenger and cargo aircraft. The FAA defines a ton-mile as, “One short ton (2,000 pounds) transported one statute mile (5,280 feet). Ton-miles are computed by multiplying the aircraft miles flown on each inter-airport hop by the number of tons carried on that hop.” Additionally, a passenger ton-mile is defined as, “One ton of passenger weight (including free baggage) transported one mile.” For both definitions see *FAA Statistical Handbook of Aviation, 1962 Edition*, (Washington D.C.: Government Printing Office, 1962), 143-144.

[12].“Lockheed's 'Big Lifter'.” *Flying Review International* 19, no. 4, January 1964, 33-37.

Chapter 3

Attempts to Field a Civil-Military Aircraft

> *No one will dispute the fact that, in the absolute sense, a plane which must meet both the civil and military requirements cannot be the perfect machine for either propose.*
>
> —Giulio Douhet
> Command of the Air

In the last forty years, the US Air Force has procured four new transport systems designed specifically for the military airlift mission that also had commercial potential. They include the Lockheed Aircraft Corporation's C-130 *Hercules*, C-141 *Starlifter*, C-5 *Galaxy*, and the McDonnell Douglas Corporation's C-17 *Globemaster III*. Each of these military aircraft systems had a commercial version of the airframe proposed or built. Each transport successfully entered operational service in the military sector, but, the majority of the commercial variants failed to enter service in the commercial sector.

This chapter examines the developmental process of three military transports to determine what inhibited or helped the development of a commercial variant. First is the Lockheed C-141. The C-141's initial concept emphasized its potential role as a civil-military transport. The commercial and military sector's cooperated during the initial developmental process with the common goal of producing a viable civil-military transport. However, despite the tremendous success of the C-141 as a military transport, the commercial versions, the L-300 and L-300B, failed to attract buyers in the

commercial sector. The second aircraft examined is the Lockheed C-130. The C-130 represents an aircraft developed for the military with no initial thought to the commercial market. However, nearly ten years after the initial roll-out, the C-130 made a highly successful jump to the commercial sector as the L-100. The final aircraft examined is the McDonnell Douglas C-17, America's newest military transport. With the military contract of 120 aircraft secured, McDonnell Douglas is seeking to market a commercial version of the aircraft, designated the MD-17.

The C-141/L-300: An Aircraft Targeted For Both Sectors

> *A new, un-compromised turbine-powered aircraft should be developed and such aircraft should, to the maximum extent possible be compatible with the economic transportation of civilian cargo by civil airlines.*
>
> —Recommendation of the Rivers Subcommittee on National Airlift, 1960[13]

The C-141 developed from a military concept first proposed in 1959. In February of that year, the Military Air Transport Service (MATS) submitted to Headquarters Air Force a request to begin the development of the next generation airlifter. By December, the Air Force drafted the requirement into a Special Operational Requirement (SOR) and granted MATS permission to begin developing the concept.

The initial planning for the SOR focused on developing a military transport aircraft with commercial potential. Along with the Air Force and Army, the Federal Aviation Administration (FAA) participated in the research process to design the SOR aircraft.[14] The FAA served as a liaison between the commercial sector and the military. They maintained responsibility for coordinating with major segments of the airline industry interested in developing a civil-military transport. The FAA not only represented the

commercial sector's concerns, they also ensured the incorporation of commercially desirable features in the SOR aircraft.

During the development process a consensus arose between the military and FAA as to the characteristics of the SOR aircraft. For the military, the SOR needed to possess strategic and tactical characteristics. For the commercial sector, the aircraft had to operate at a lower cost than any other cargo aircraft in the same category. The commercial requirement was critical if the SOR was to penetrate the cargo market. What emerged was a consensus that the aircraft needed to fly at 440 miles per hour, yet maintain the ability to fly slow enough to allow the aircraft to drop paratroops.[15] The SOR aircraft also had to be capable of landing at intermediate length airfields in the 5,000 foot range and it needed the ability to operate in areas with minimal loading and unloading equipment.[16] This meant that the cargo deck in the fuselage had to be close to the ground.

The SOR concept received strong political support from the Subcommittee on National Military Airlift of the House Committee on Armed Services when it convened in 1960. Representative L. Mendel Rivers, a long time airlift advocate, chaired the subcommittee. During the course of the hearings the subcommittee noted deficiencies in the nation's cargo airlift and heard testimony concerning the SOR. The subcommittee strongly supported the development of a transport that could meet the needs of the commercial sector and the military.[17] To further the SOR project, Representative Rivers appeared before the House Committee on Appropriations on March 30, 1960, and during his testimony urged the development of a civil-military transport. Furthermore, he recommended that SOR development become “a matter of first priority.”[18] To support

the joint developmental effort, the Rivers Subcommittee adopted a motion for the House Appropriations Defense Subcommittee authorizing the Air Force $50 million to develop a civil-military transport.[19] Despite the funding, the project did not advance to the point where a contract could be let prior to the upcoming presidential elections.

The 1960 presidential election focused attention on national defense and airlift in particular. The Kennedy campaign focused on what it saw as deficiencies in national defense, and airlift became a major theme for the campaign. Once elected, the Kennedy administration made airlift a top priority. In his first State of the Union address before Congress on January 30, 1961, President Kennedy stated, "Obtaining additional air transport mobility--and obtaining it now--will better assure the ability of our conventional forces to respond with determination and speed, to any problem at any spot on the globe, at a moments notice."[20] It was with this tone that the Administration began a robust acquisition of airlift.

In January 1961, the White House announced it was seeking bids to produce SOR aircraft, now designated the SOR 182. The Administration received submissions from Boeing Aircraft Company, the Douglas Aircraft Company, Lockheed Aircraft Corporation, and Convair.[21] Three months later, in March, the Kennedy administration awarded Lockheed a $1 billion contract for the development of a civil-military transport. Lockheed designated the Air Force version the C-141 and the commercial variant the L-300.

To insure commercial sector input in the development of the aircraft, the Administration asked the Airline Transport Association (ATA) to participate. The ATA maintained a liaison between the military and the larger scheduled carriers.[22]

Despite the ATA's participation, the initial plans for the C-141 took on a military flavor. The ATA's interest in the project began to wane as military capabilities dominated the aircraft's characteristics. The military stipulated that the C-141 be able to operate on rough fields, airdrop 118 paratroops, and permit straight-in cargo loading from under the tail.[23] The ATA contended many of the military requirements had little value in the commercial sector and decreased the attractiveness of the L-300. Despite the ATA's objections, the project maintained its military focus. For the ATA, it became clear that the C-141 would not satisfy the needs of the commercial sector.

In late 1961, the ATA announced its withdrawal from the project and cited several reasons for ending its participation. First, the ATA felt that the project focused too much on the military requirements to produce a commercially viable aircraft.[24] Second, the Association felt that the cargo compartment was too large for the current commercial market.[25] With the ATA's withdrawal, the scheduled carriers ended their participation in the project. However, there was still significant interest among the nonscheduled cargo carriers who derived much of their business from government contracts.

Despite the setback, Lockheed continued its efforts to market the L-300. In March 1963, Lockheed offered the first L-300 to Flying Tigers for about $6 million per aircraft.[26] However, Flying Tigers never placed an order for the L-300. Furthermore, Lockheed was unable to sell a single L-300 to a commercial carrier.[27] The high cost of the L-300 combined with its inability to offer a significant economic advantage in the air cargo niche handcuffed Lockheed's marketing of the aircraft.

Nevertheless, Lockheed began to look for other ways to improve the L-300's marketability. Lockheed consulted domestic and foreign carriers to determine how to

enhance the aircraft for the commercial market.[28] The concept that emerged was a stretched L-300 that increased the cargo capacity of the aircraft.[29] Lockheed adopted this option and the result was the L-300B.

The L-300B possessed significant improvements in the cost per ton-mile calculations used to determine the efficiency of a cargo transport. The ATA calculated that an L-300 could move cargo at a rate of 4 cents per ton-mile over routes of 1,400 to 3,550 miles and at 5 cents per ton-mile for routes of shorter lengths.[30] The L-300B with its extended cargo compartment offered much more competitive rates. The long haul rate calculations improved to 3.5 cents per ton-mile and for distances as short as 500 miles the rate would be around 4.25 cents per ton-mile.[31] Lockheed calculated that the L-300B could operate more efficiently than the Boeing 320C and the Douglas DC-8F.[32] Both the 320C and the DC-8F were cargo aircraft based on commercial passenger designs. Based on the new low ton-mile estimates Slick Airways and Flying Tigers, both non-scheduled carriers, placed orders for the L-300B.[33]

Despite the orders, Lockheed never produced the L-300B. With only a small number of L-300Bs on order, Lockheed was unwilling to commit the necessary corporate assets to begin production.[34] To make the venture profitable, Lockheed needed a large order for stretched C-141s from the Air Force.[35] The possibility of an Air Force purchase of a stretched C-141 evaporated when the Air Force began exploring the production of an even larger cargo transport.

A major factor in the L-300s lack of commercial success was the aircraft's high cost. Many commercial carriers maintained lean balance sheets and re-capitalization with L-300s or L-300Bs were either beyond their means or at best, a risky proposition. The Air

Force and Congress also contributed to keeping the cost of the aircraft high by stipulating that any company purchasing a L-300 would pay a share of the developmental costs.[36] This helped increase the cost of the aircraft to a point that commercial carriers would buy them only if the government met one of the following conditions:[37]

1. Provide guaranteed loans;
2. Guarantee contracts necessary to keep the aircraft's operation profitable; or
3. Provide the carrier with subsidies.

Each of these conditions lowered the risk for the commercial sector by transferring some of the risk to the government.

Air Force policies in the early 1960s also affected efforts to sell the L-300. Due to the research and development schedule, the first L-300s would not enter the commercial sector until 1965 and this did little to alleviate current airlift shortage.[38] To help overcome the shortfall the Air Force encouraged commercial carriers to purchase new aircraft. The Air Force considered these purchases an "interim" measure and expected the commercial carriers to purchase L-300s when they became available.[39] The airlines were willing to upgrade their fleets to help prevent the loss of lucrative Air Force contracts.[40] As a result, many carriers purchased cargo aircraft currently in production. These aircraft included the Boeing 320C, Douglas DC-8F, and the Canadian built CL-44.[41] However, because of the cost of these aircraft, the air carriers extended the depreciation schedule to 12-14 years.[42] As a result, the airlines were unwilling to replace fairly new aircraft with L-300s.

By 1963, all political support for the L-300 had evaporated. Any hope that the L-300 was going to make it as a commercial aircraft dimmed during the 1963 House National

Military Airlift Hearings. While testifying at the hearings, Secretary of Defense Robert McNamara stated that it was the Administration's goal to "quadruple" the airlift capacity of MATS.[43] When questioned concerning the impact of these aircraft on the availability of contracts for the commercial sector, McNamara responded, "I have no plans to increase the contractual arrangement with the civil carriers."[44]

There were two ways the commercial sector could interpret McNamara's comments. First, they could make the optimistic appraisal that the number of contracts would remain stable in the coming years. Second, a pessimistic interpretation would see the relative level of contracts dropping since a larger MATS could move more of the current contract cargo as a byproduct of training. This could significantly reduce the number of contacts available to the commercial sector.

McNamara further alienated the non-schedule carriers by stating that any airline that derived 70-80% of their business from government contracts provided little in the way of reserve capacity.[45] Furthermore, he stated, "I think we are deluding ourselves if we believe we are buying any real military capability from a civil airline that devotes the great majority of its time to transporting military equipment. We might just as well buy the equipment and operate it ourselves."[46] McNamara then proceeded to discuss the follow-on to the C-141, the CX-4. This aircraft would become the C-5A.

The development of the CX-4, a newer and larger cargo transport further stymied attempts to sell the L-300 or L-300B. The new aircraft promised a larger cargo capacity than the L-300. When the Administration announced that Lockheed was the prime contractor for the CX-4,now designated the C-5A, Lockheed also announced a

commercial version of the aircraft, the L-500. Many companies that expressed an interest in the L-300 decided to wait for the larger L-500.[47]

At this time Lockheed was also beginning the production of a commercial version of the C-130, the L-100. This also helped limit the effort placed on marketing the L-300.[48] Additionally, this positioned the L-300 in the middle of two other Lockheed transports vying for a position in the commercial market. While there was commercial interest in all three aircraft the highest potential for sales was in the L-100 and the L-500.

A final factor hindering the development of the L-300 was the growing cargo market. In the early 1960s, the FAA projected high annual growth rates for the cargo market. In fact, the growth rate was 22% in 1961, and 20% in 1962.[49] Cargo transport had always been the stepchild of the airline industry, however, it was now becoming an important source of income for many carriers. As a result, there was a rush to purchase cargo aircraft and to convert under-utilized passenger aircraft to cargo configurations. Thus, by 1963, increased competition lowered cargo transportation charges, reducing the profit margins for cargo carriers.

For Lockheed, the C-141/L-300 saga was bittersweet. The C-141 became the core of America's airlift fleet for over 30 years and represented a tremendous success. However, the L-300 failed to enter commercial service, even when it offered a significant competitive advantage (i.e., the L-300Bs lower cost per ton-mile) in the marketplace.

The C-130: A Civil-Military Success Story

> *Lockheed's Super Hercules is ... ideal for military or commercial airfreight operations in the United States and foreign countries. A growth version of Lockheed's very successful C-130 design, the Super Hercules*

offers ... a rugged, economical "work-horse" aircraft, the Super Hercules is suitable for a wide variety of military and commercial applications.

Lockheed Aircraft Corporation,
Promotional Brochure, 1959[50]

The C-130 is by far the most successful military transport design in aviation history. Since the first roll out of the YC-130 in 1954, the Lockheed Aircraft Corporation has developed over 50 variants of the aircraft.[51] However, the C-130 has another major distinction in aviation circles. It is the only large US built transport aircraft designed for military operations that has made a successful jump into the commercial sector. Of the 50 variants developed, Lockheed produced four versions specifically for the commercial market.

The concept for the C-130 emerged in the wake of the Korean War. War planners realized that the Air Force's current theater airlift fleet was unable to handle much of the Army's heavy support equipment and lacked the range planners desired.[52] As a result, the Air Force issued the General Operating Requirements for a new transport. The Air Force was seeking "a medium transport...to perform tactical and logistical missions" with a range of 2,000 miles, 30,000 pound payload, and airdrop capable.[53] The Lockheed Aircraft Corporation won the contract and rolled out the YC-130 on August 23, 1954.[54]

Lockheed did not ignore commercial potential of the C-130. In 1956, Lockheed polled 100 air carriers to determine what characteristics they wanted in the next generation cargo aircraft.[55] Eighty percent of the carriers surveyed desired the following characteristics:[56]

1. A cargo deck that was only 40-50 inches off the ground,
2. A pressurized cargo compartment, and/or
3. An aircraft that could operate on runways of 5,000 feet.

Additionally, they desired straight-in loading if the rapid on-loading and off-loading could offset the economic disadvantages of the added weight and the potential loss of speed.[57] The desired payload requests ranged from 20,000 to 60,000 pounds, with the 50,000 to 60,000 category receiving over 50 percent of the requests.[58] It is important to note that the characteristics Lockheed identified in 1956 bear a striking resemblance to those identified by the Air Force and the FAA in the SOR 182 study.

With this information the Lockheed Aircraft Corporation began its own developmental program to produce a freighter that would satisfy the needs of the commercial sector. In the late 1950s, Lockheed touted two versions of the C-130 airframe for the commercial market. The first version was the *Hercules Airfreighter*. This aircraft was a commercial version of the military production C-130. However, it failed to attract commercial buyers. The second model was a C-130-based design with slightly larger and more powerful engines than the *Hercules Airfreighter*.[59] Lockheed designated this aircraft the GL-207 and dubbed it the *Super Hercules*.[60] Initial commercial interest in the GL-207 was strong. Based on the initial concept, Pan American World Airways ordered 12 aircraft and Slick Airways placed orders for six of the large turboprop aircraft.[61] However, the project came to an end when both Pan America and Slick canceled their purchases.[62]

Two factors contributed to the cancellation of the GL-207 contracts. The first factor was the 1959 Air Force decision to cancel development of the Allison T61 turboprop. This engine was to power the GL-207 *Super Hercules* and would allow the aircraft to carry a payload of 77,000 pounds.[63] In an effort to keep the GL-207 alive Lockheed tried

to substitute the T61 with less powerful Rolls-Royce Tyne Turboprops. However, this less powerful engine limited the gross weight of the aircraft to 230,000 pounds, resulting in a loss of 20,000 pounds of cargo capacity.[64] The second factor involved advances in turbofan engines and in swept wing design. Aircraft with these characteristics were fast becoming the future of large cargo transport aircraft and both C-130 versions had neither characteristic.

With the cancellation of the GL-207 and the lack of orders for the *Hercules Airfreighter*, Lockheed shelved plans for a commercial turboprop cargo aircraft based on the C-130. Lockheed, using its experience and expertise developed from the C-130 and GL-207, focused its efforts on developing a jet transport. This research eventually resulted in the C-141 and L-300 concept; however, as previously discussed, the L-300 attracted very little commercial interest. However, Lockheed did not completely give up on the commercial C-130 concept and re-evaluated the aircraft's commercial potential four years later.

In the early 1960s, as Lockheed analyzed market trends they were quick to note two major factors that could influence the marketability of a C-130 based civil transport. First, Lockheed noted the potential emergence of a cargo niche market ideally suited for a commercial version of the C-130. This niche market was immune to the stagnating international cargo market.[65] Spurred by an increase in mineral exploration in remote areas, Lockheed felt there was a niche market for a commercial transport with the rugged features of the C-130.

The second factor that influenced the decision to produce a commercial version was the pending completion of military's C-130 order. Lockheed recognized that military

production would begin to taper off in the mid-1960s. This would allow Lockheed to dedicate a portion of the production line to producing a commercial version of the aircraft. In 1963, the company again decided to produce a commercial version of the C-130, designated the L-100.

This time, Lockheed employed a different corporate strategy than the one used in the 1950s to sell the first commercial versions of the C-130. To spur commercial interest in the L-100, Lockheed built a demonstrator aircraft rather than attempting to sell the aircraft based on plans. Attempting to obtain and maintain contracts without a flying airframe proved a difficult if not impossible task for the *Hercules Airfreighter*, GL-207 *Super Hercules*, and the L-300. However, with the L-100, Lockheed planned to produce the aircraft first and showcase its abilities while soliciting contracts. Thus, during the 1963 production cycle, Lockheed identified a Model 382 airframe in the production line and designated it the L-100. [66] Lockheed modified the aircraft with commercially-rated engines and produced it in accordance with FAA certification requirements.

From the start of testing, Lockheed showcased the L-100 capabilities to impress potential commercial customers. On the L-100's first flight, on April 20-21, 1964, the aircraft logged 25 hours and 1 minute aloft and set a record for the longest commercial aircraft flight.[67] Equally as impressive as the flight's length was the fact that all but 36 minutes of the flight was on two engines.[68] Following the inaugural flight, the aircraft embarked on a series of demonstration flights designed to generate interest in prospective customers.[69] With potential customers aware of the L-100 capabilities, Lockheed then submitted the aircraft for FAA certification.

The FAA certified the L-100 on February 16, 1965, and within a month, the aircraft was flying commercially in the niche market targeted by Lockheed. Lockheed leased the demonstrator aircraft to Alaska Airlines. Lockheed considered Alaska Airlines and their main competitor, Alaska International Air, prime candidates for L-100 sales.[70] Mineral and oil exploration in Alaska was expanding and the transportation of men and equipment into the remote wilderness posed major problems. The cost of moving heavy equipment overland was extremely expensive and time consuming, and winter freeze limited movement via water to a few warm months of summer. Further complicating shipping operations was the fact that the majority of the heavy equipment came from the continental US. This added a considerable length to the shipping time and greatly increased the cost for heavy equipment.

To aid in sales, Lockheed enhanced the L-100s attractiveness with an aggressive and creative marketing plan. They adopted a sale/lease technique commonly used in the passenger aircraft market. On one hand, Lockheed pursued the sale of aircraft to commercial companies that were capable of maintaining contracts necessary to keep the company solvent; while on the other hand, they leased additional aircraft through leasing companies and financing corporations.[71] The leasing option satisfied the needs of many companies who operated lucrative, but relatively short duration contracts. This arrangement also gave Lockheed some control over the market.

The leasing of aircraft proved extremely effective in maintaining the L-100 market. By maintaining control over leased aircraft, Lockheed was able to leverage a portion of the market, preventing over-saturation. An additional benefit of the leasing arrangement

was that when a lease expired, Lockheed could refurbish and update the L-100. This prevented the accumulation of outdated aircraft in the L-100's niche market.

A prime example of how Lockheed used the sale/lease technique to leverage the market was its "stretch" of the L-100. In 1967, Lockheed terminated the production of L-100s and in early 1968, introduced the stretched version--the L-100-20. The L-100-20 had an extra 100 inches added to the cargo compartment. Lockheed accomplished the stretch by placing a 60 inch fuselage "plug" aft of the cockpit and a 40 inch plug aft of the wing. To leverage the commercial market Lockheed retrofitted each L-100 that returned after the completion of a lease with the L-100-20 plugs.[72] Additionally, Lockheed repurchased several L-100s and refitted them to the -20 configuration.[73] This move had several major influences on the market. It prevented the accumulation of L-100s, kept the leased fleet updated, and offered owners of L-100s the opportunity to upgrade their aircraft. The end result was that Lockheed converted numerous L-100s, both leased and sold, to the -20 configuration.

The success of the -20 stretch spawned consideration of an even larger stretch of the basic L-100. Customer satisfaction with the initial stretch played a significant role in Lockheed's decision to add another version to the L-100 line.[74] Further adding to their decision was Lockheed's determination that a slightly larger L-100 could operate as a feeder-line freighter for larger cargo aircraft.[75] As a result, the L-100-30 went into production in 1970.

The L-100-30 is the same L-100 airframe with the addition of two larger fuselage plugs. This addition gives the aircraft an additional 180 inches of cargo space and increased the number of pallet positions from six in the L-100 to eight in the L-100-30.

This stretch was more successful that the -20 stretch. In fact, Lockheed converted all but one remaining L-100 to the -30 configuration.[76]

Lockheed has over the years continued to expand the horizons of the L-100 series. First, in 1983, Lockheed pursued FAA passenger certification for the L-100-30. Subsequent to 1983 the FAA only certified the L-100 as cargo aircraft. With FAA passenger certification completed, the C-130 design made the jump from the military sector into cargo and passenger segment of the commercial market.

Recently, Lockheed developed another version of the L-100. The aircraft is the L-100J, a commercial version of the military C-130J. This aircraft is presently undergoing FAA certification testing. Lockheed expects this process to be complete in May 1997.[77] However, to date there have been no commercial sales of the L-100J.

There is one more significant postscript to the L-100 story. The success of the L-100-30 in-turn influenced the military market. Smaller nations who were unwilling to or unable to afford larger transports found the L-100-30 ideal for their military operations. The result was the creation of a stretched version of the C-130 for the military market.[78] Thus, the developmental cycle of the C-130 came full circle as the L-100-30 entered the military sector.

Summarizing the Lockheed Experience

The L-300 and L-100 case studies show that a myriad of factors influence the viability of a civil-military transport. In each of the cases, the role of politics, technology, and economics differed. Many of these differences contributed to the failure of the L-300/L-300B and the success of the L-100. These cases also highlight the importance of

several factors such as market entry timing and the viability of the targeted niche market. Within these two case studies are valuable lessons for aircraft manufactures considering the development of a civil-military transport.

Politics played an important role in the initial development of the L-300. Governmental support served as the catalyst for the development of the commercial version of the C-141. However, the government failed to maintain an active interest in the civil-military aspects of the project; particularly, following the ATA's withdrawal from the project. For example, the SOR was not a topic of discussion during the 1963 House National Military Airlift Hearings. Instead of examining the faltering SOR program, the committee heard testimony concerning the next generation airlifter. Additionally, the government further hindered Lockheed's attempts to sell the L-300 by allowing the Air Force to reclaim developmental costs on any commercial version sold. This helped make the L-300 a costly and questionable investment for potential commercial buyers.

Conversely, the L-100 remained free of political intervention. The impetus for the L-100's development as a civil-military transport was due to the aircraft's economic viability, not political support. This allowed Lockheed to develop a solid corporate strategy for the aircraft. Additionally, it allowed Lockheed to take full advantage of economic growth in a niche market ideally suited to the L-100 capabilities.

Economic growth in the L-300 and L-100 targeted niche also influenced their success as civil-military transports. In the early 1960s, the niche market targeted by the L-300 began to rapidly expand. To meet the growing demand, many commercial carriers expanded their cargo fleets. To secure new aircraft, companies looked to two sources.

The first source was new cargo aircraft currently in production. The second source was passenger aircraft converted to a cargo configuration. Since the L-300 and L-300B were still on the drawing board, potential buyers bypassed them. When the L-300 and L-300B was finally available, the aircraft could not significantly compete in the cargo market.

The L-100 and L-300 case also emphasize the need to enter the market place as a niche market is expanding. Lockheed, in the early 1960s, recognized that a niche market supporting mineral exploration was emerging and they made the corporate commitment to have the L-100 ready to exploit the emerging market. Capabilities such as oversize capacity and rough field operations were not available in the commercial sector and Lockheed timed the L-100's market entry to fill the void. Conversely, the L-300 missed its best “window of opportunity” by attempting to enter the commercial market two to three years after the rapid growth period. By then, even the technological and economic advantages offered by the larger L-300B, could not displace aircraft currently operating in the niche market.

Another factor that influenced the success of the L-100 was Lockheed’s marketing strategy. To stir market interest, Lockheed built a demonstrator aircraft and with a series of promotional flights, showcased the aircraft’s abilities. Following the flights, Lockheed employed a sale/lease strategy to facilitate the aircraft’s entry into the commercial sector. This strategy attracted air carriers who could afford the aircraft and also added a number of customers who needed the aircraft, but could not afford to buy it outright. This strategy also aided in expanding and maintaining the L-100’s niche market. Additionally, by leasing aircraft, Lockheed could leverage the market’s growth by controlling the number and quality of aircraft operating in the niche.

A final factor that influenced the commercial marketing of a civil-military transport is the importance of a strong military production run. The L-300B best exemplified how a military production run catalyzes the commercial version. This version of the aircraft offered the commercial sector the competitive advantage the L-300 lacked; however, without a military order for stretched C-141s, Lockheed was financially unable produce the aircraft on its own. A second example of the need for military investment to catalyze the commercial market was the cancellation of the *Super Hercules*. Without the military sponsoring the development of the T61 engine, the entire project collapsed.

Each of these factors helped influence the success or failure of the civil-military transport. From these two case studies it is apparent that there is no single cause for an aircraft's failure as a civil-military transport. Conversely, there is no sure formula for success. Future civil-military transports can, however, look to the developmental process of these two aircraft for potential indicators of success or failure.

The C-17 and the MD-17: The Next Civil-Military Transport?

Versatile and efficient, the MD-17 will revolutionize the transportation of heavy and outsize goods. Big Jobs. Little places. No problem.

—McDonnell Douglas, 1997

The C-17 is America's newest military transport aircraft, and like its predecessors, the military version has a proposed commercial variant, the MD-17. Like the L-100, the MD-17 is an off-shoot of a military airlift program that is making a serious bid to enter the commercial sector (see figure 2 in chapter 2). The aircraft's maker, McDonnell Douglas, is in the first year of a major corporate push to sell the MD-17 commercially and it is likely the MD-17 story will continue to develop over the coming years. To date, no commercial versions of the aircraft are on order or in production; however, McDonnell Douglas is aggressively marketing the MD-17 worldwide.

McDonnell Douglas first considered developing a commercial version of the C-17 in 1989.[79] However, McDonnell Douglas set the project aside for two reasons. First and foremost was the company's worsening financial condition. McDonnell Douglas was not in position to assume the financial burden associated with a new project. Secondly, at the time, demand for outsize capability in the commercial sector was almost nil. This is due to the fact that prior to 1989 there was little outsize capacity available to the commercial sector. Typically, if a corporation needed to move a large piece of heavy or outsized equipment via air, the only option was to contract with the military. On extremely rare occasions the military provided the service; however, it proved to be a very expensive solution. This changed in 1989 when for the first time outsize capability appeared in the commercial sector.

In 1989, the Cold War came to an end and many former Soviet states began to experiment with capitalism and market based economies. In the rush to embrace capitalism many of the former Soviet block countries looked for every possible way to raise hard currency. One such arena was air transport. The Soviet military machine amassed a tremendous airlift fleet and the aircraft now represented an opportunity to earn hard currency. To exploit the fleet's potential, an enterprising British firm began to broker missions for two of the Ukrainian built Antonov An-124s and for the first time there was outsize capability in the commercial sector. The success of this venture proved that there is a niche market in the commercial sector for outsize cargo.

With an established outsize niche market, McDonnell Douglas again addressed the possibility of a commercial version of the C-17. In 1993, McDonnell Douglas began a series of informational talks with prospective customers, including Federal Express and United Parcel Service, to determine if there was interest in a commercial version of the C-17.[80] Neither company placed an order for the MD-17; however, McDonnell Douglas continued to research potential markets for the aircraft.

Despite the growing outsize cargo market and interest in the MD-17, McDonnell Douglas, again, was not in position to begin full scale development. Like the L-300B, the production of the MD-17 depended on an Air Force buy of the military version. Early in the 1990s, troubles with C-17 contract began to increase. The production schedule was behind, the wing had just failed a major stress test, and the overall cost of the program was rising. With management and production problems the future of the C-17 was in jeopardy. Then, things went from bad to worse when Under Secretary of Defense for Acquisition and Technology, Dr. John Deutch, placed McDonnell Douglas on probation

and gave them two years to correct the problems with the C-17 program or face a major reduction in the number of aircraft purchased. Like previous civil-military programs (L-300B and T61 Turboprop), the government contract was to serve as a springboard for the commercial venture. With the C-17 on the line, McDonnell Douglas regrouped and began an attempt to turn the program around.

The turnaround at McDonnell Douglas rekindled the chances of the MD-17. During the probation period, the McDonnell Douglas program manager, Mr. Don Kozlowski, worked closely with the new Air Force program director, Brigadier General Ronald T. Kadish, to restructure the program and ensure that all probationary requirements were complied with. Additionally, McDonnell Douglas revamped their management style and adopted a team concept in production. As a result, the program went from 173 days behind in deliveries to ahead of schedule deliveries for every aircraft since aircraft P-13 rolled off the line on June 29, 1994.[81]

Like the L-100s high profile market entry, the C-17's initial performances are showcasing the potential capabilities of the MD-17. For example, the C-17's initial Reliability, Maintainability, and Availability Evaluation conducted in 1995 achieved a 99% launch reliability.[82] To further bolster the aircraft's image, the Air Force flies the C-17 on many high visibility missions that attracted attention to the airframe. The highly successful operational assessment and operational use of the C-17 culminated with a Department of Defense decision to purchase an additional 80 C-17s bringing the total number procured to 120. While none of these factors directly contribute to the development of a civil-military aircraft, they played an important role in showcasing the aircraft's potential to the commercial sector.

With the military contract secured, McDonnell Douglas began aggressively marketing the commercial version. To aid in the marketing, McDonnell Douglas gave corporate authority for active negotiations with prospective buyers in December 1996. This allows the Military Sales Division, who handles the MD-17, to negotiate aircraft specifications and price with prospective air carriers.

The next major step that McDonnell Douglas will face is the decision to launch production. McDonnell Douglas needs between five to twelve orders to begin commercial production of the MD-17.[83] Since McDonnell Douglas plans to produce the MD-17 and C-17 on the same production line, tooling is a critical factor. The line is presently capable of producing a maximum fifteen aircraft a year; however, this could surge to twenty aircraft a year with some additional tooling.[84]

Presently, the production line is dedicated to fulfilling military contracts. Under the new Multi-Year Procurement contract signed with the Air Force, the maximum number of C-17 produced in any one year is fifteen.[85] This leaves as many as five positions open for Foreign Military Sales (FMS) and Direct Commercial Sales (DCS) of the C-17, or commercial sales of the MD-17.[86] This allows McDonnell Douglas the ability to produce commercial versions of the aircraft without impacting the Air Force contract.

However, two governmental decisions will influence the success of the MD-17. First, is the State Department's controlled munitions list. The State Department monitors all sales of military related technologies to insure that military capabilities do not enter the commercial sector. Removal from this list is mandatory if the MD-17 is to enter production for worldwide sales. To make compliance easier and reduce the MD-17's cost, McDonnell Douglas will remove militarily significant capabilities such as air

refueling and the nitrogen generating system that prevents fuel tank explosions due to small arm's fire.[87] While the MD-17 capabilities represent a technological improvement over current commercial transports, it is not likely that the State Department will restrict its sale. Especially since Russian and Ukrainian made aircraft with similar capabilities are operating in the commercial sector.

In rendering a decision, the State Department will rely heavily on the Air Force's opinion as to the need to keep this technology out of the commercial sector. In the past the Department of Defense's opinion has been pivotal in such cases. Thus, the Air Force will have a major role in determining the viability of a MD-17 as a civil-military transport.[88]

The second major governmental hurdle for the MD-17 is FAA certification. This is a time consuming process that can take up to four years to complete and requires a flying prototype.[89] To shorten the MD-17 certification time, McDonnell Douglas plans to use Air Force test data (with Air Force permission) accumulated during the C-17 testing process.[90] During the Air Force acceptance of the C-17, the aircraft amassed over 39,000 hours of test data,[91] much of which the FAA can accept for the certification process.[92] The sharing of data allows the FAA certification process to begin without a flying MD-17. However, this will not alleviate the need for a flying MD-17 to complete the certification process.[93]

If the State Department and FAA rule in McDonnell Douglas's favor, the process will be all for naught if the MD-17 is not commercially viable. This remains the prime concern of McDonnell Douglas marketers since the projected cost of the MD-17 is $175 million dollars per unit.[94] To determine the commercial viability of a MD-17, McDonnell

Douglas has analyzed several potential niche markets the MD-17 can operate in. These niches do not include the bulk and oversize markets served by large freight aircraft such as the 747-400F or the MD-11F. Instead, McDonnell Douglas is targeting three specific cargo niches. First, they hope to expand the niche the L-100 created, second is to further exploit the outsize cargo niche, and third is to create a niche specifically for the MD-17.

In targeting the established niche market, McDonnell Douglas will attempt to enter and expand the same market that the L-100 established thirty years earlier. The L-100 is an aircraft that hauls construction equipment into remote locations when surface movement proves cost prohibitive or physically impossible. The MD-17 can further expand this market with its short-field and outsize capabilities. McDonnell Douglas is confident that recent increase in mineral exploration, especially in Russia, will increase demand for the airlifting of heavy equipment.[95]

McDonnell Douglas feels this niche also extends into the construction market. McDonnell Douglas points to the airlifting of an entire Coca-Cola production plant to Siberia as an example.[96] By airlifting the plant, operations began much faster. Thus, the plant was generating revenue much faster than if shipped via the surface. McDonnell Douglas feels that the many large construction projects, especially in China and other developing countries, will benefit from the MD-17 capabilities.[97]

McDonnell Douglas also hopes to exploit the niche dominated by the An-124. Given the An-124's low reliability record of 55%, this market is extremely vulnerable to competition.[98] Presently, there are twelve An-124s in commercial use.[99] McDonnell Douglas estimates the growth of the outsize and heavy-lift market will support the An-124 fleet and over 32 MD-17s over the next fifteen years.[100]

McDonnell Douglas is also focusing on a new niche market. This untapped market is presently sitting in the hulls of sea-going cargo ships. McDonnell Douglas hopes to capture a small percentage of the worldwide the trade in sea-going cargo. Worldwide, the shipping industry is an $8 billion a year business.[101] While the vast majority of the cargo is not worth moving via air, a small percentage is time sensitive and/or expensive equipment. For example, a single shipping container can accumulate over $38,000 in additional costs during a 30 day shipping period.[102] McDonnell Douglas states that a MD-17 can carry seven containers, providing a significant monetary and time savings to companies who normally use ships.[103] With an estimated flying hour cost of $12-15,000 per hour the MD-17 could substantially undercut a portion of the seaborne market and obtain access to a small percentage of the highest value cargo.[104] McDonnell Douglas believes that this untapped market could result in the production of hundreds of MD-17s.[105]

McDonnell Douglas is also touting the MD-17 as an ideal addition to the Civil Reserve Air Fleet. A military requirement that McDonnell Douglas feels the MD-17 is capable of handling is the time-sensitive disaster and humanitarian relief missions currently operated by military aircraft. Based on a review of Air Mobility Command's 1995 Special Assignment Airlift Missions the portion of these missions that was commercial eligible is between 170 and 200.[106] These missions alone cannot keep an MD-17 busy enough to make it profitable; however, they can provide additional revenue for a MD-17 operator.

The MD-17 is a case study that is still ongoing and it is a civil-military story that will continue to develop in the coming years. However, even at the early stages of the

aircraft's marketing, the MD-17 program bears numerous parallels with the L-100 and L-300 programs. For example, all three civil versions of the aircraft required a large production run of the military version. While this does not guarantee the success of the MD-17, it will help provide a solid foundation from which to launch the commercial version. Second, the MD-17 highlights the importance of targeting the correct niche markets that exploit the aircraft's capabilities. In this respect, the MD-17 is following the same path as the L-100. A final negative factor the MD-17 has in common with the L-300 is high cost. In the 1960s, the high cost of the L-300 helped inhibit its and success high cost also poses the most serious hurdle for the MD-17.

Summary

If there is one consensus that can be drawn for these case studies it is that there is no formula for success and any number of variables can influence the developmental process. Civil-military transports are vulnerable to a myriad of factors, each that could potentially inhibit the program. They are vulnerable to policy changes, changes in military procurements, timing, and most importantly, the marketing niche for the aircraft. While it is certain that no single factor can guarantee success, it is equally certain that a single factor, if ignored, can kill a civil-military transport. Additionally, these case studies have shown that the success of a civil-military transport is not only aircraft dependent, but also situation and niche dependent.

Chapter 4

The Changing Context

> *In the 21st Century, Rapid Global Mobility will be multi-faceted. Better use of commercial carriers will be made to increase the efficiency of Air Force mobility.*
>
> —Air Force Core Competency:
> Rapid Global Mobility[107]

This chapter looks at several of the major contextual factors that presently influence the viability of civil-military transports as discussed in Chapter Three. First, it examines changes in the commercial sector. Factors such as overall market growth, niche market growth, the composition of the commercial fleet, and projected aircraft production levels can influence the fielding of a contemporary civil-military transport. Second, this chapter looks at changes in the military. It examines the current state of the military fleet, its long-term composition, and changes in the acquisition process. Considered together, the commercial and military sector has undergone significant change that may support the civil-military concept.

Changes in the Commercial Sector

The commercial sector has undergone numerous changes that influence the viability of a civil-military transport. Overall, there has been consistent long-term growth in the commercial air cargo market and in the niche markets that might favor a civil-military

transport. Additionally, the composition and size of the cargo fleet is changing and this may exert a positive influence on the development of a civil-military transport. Fleet dynamics such as the age of the air cargo fleet, "combi" aircraft purchases, and the conversion of passenger aircraft to freighters are also changing. This section examines each of these factors and their potential impact.

The air cargo market is steadily expanding and is forecast to remain healthy for the next 20 years. According to Frank F. Caton, president of the Cargo Shipping Transportation Analysts, a growth rate of over 6% per year through the year 2014 is likely.[108] The major airframe manufacturers agree with this assessment and project a 6-8% per year growth rate.[109] This steady growth translates into a "quadrupling" of air cargo traffic by the year 2015.[110] The driving force behind air cargo growth is the shift to just-in-time manufacturing procedures that have time-definite delivery schedules.[111] However, market growth within the air cargo industry is not enough to secure a guarantee that civil-military transport can compete.

More important than overall market growth, is the growth rate within the niche in which a civil-military transport will compete. A prime example of where a civil-military transport can compete in today's market is in the outsize cargo niche. For example, in the first few years, this emerging market grew at a phenomenal 500% per year.[112] The rapid growth of this new market has stabilized and is projected to grow at a rate of 10-12% per year through the year 2015.[113]

An important factor within the outsize cargo niche market is the competition a civil-military transport will face. Presently, the An-124 dominates the outsize cargo market. However, given its poor reliability, a civil-military transport with outsize capability could

penetrate the market niche and control market share based on reliability alone. This assumes that a civil-military transport can enter service prior to an improvement in the An-124's reliability. Additionally, only aircraft with outsize capability can compete in this niche. Cargo aircraft such as the 747-400, MD-11, and other freighters pose no threat to this niche market since they are incapable of carrying outsize cargo. Both of these factors favor the development and market entry of a civil-military transport suited for the outsize cargo niche.

The steady growth rate of the air cargo market and outsize cargo niche will influence the size and composition of the commercial fleet. Based on internal studies, Boeing and McDonnell Douglas are predicting that the air freighter fleet will double in size. The size of the current cargo fleet ranges somewhere between 1,200 and 1,300 aircraft.[114] However, regardless of today's fleet size, Boeing predicts a fleet of 2,219 aircraft and McDonnell Douglas the fleet size at 2,720 by 2015.[115] The bottom line is that commercial sales of new aircraft will remain strong over the next 20 years as aircraft producers' cash in on market expansion.

Another factor that will influence the viability of a civil-military transport is the trend towards larger aircraft. In addition to the doubling of the air cargo fleet by 2015, the overall ton-mile capacity is expected to triple in the same time period.[116] In simple terms, the trend is towards "large" cargo aircraft.[117] McDonnell Douglas estimates that the fleet of large cargo aircraft (those with a capacity above 77 tons) will increase from the current level of 184 aircraft to 820 by 2014.[118] This aircraft class includes the Boeing 747, McDonnell Douglas MD-11, the proposed McDonnell-Douglas MD-17, or possibly a new civil-military transport design.

Despite the predicted growth, two factors could limit the production of new large capacity transports. First, the number of passenger aircraft converted to freighters could lower new cargo aircraft purchases. Converted aircraft are expected to comprise the majority of the cargo fleet through the year 2015; however, their percentage in the fleet should not exceed 70%.[119] One factor that contributes to the 70% cap is the increasing emphasis on throughput in the commercial sector. As freight carriers demand higher utilization rates, inefficient converted aircraft will become more and more uneconomical.[120] This trend favors the development of a civil-military transport that incorporates military features that enhance throughput.

A second factor that influences the balance of the cargo fleet is the "combi" aircraft. Combi aircraft are designed to carry cargo and passengers on the same leg. Many air carriers purchased these aircraft as a means of exploiting both the passenger and cargo markets. However, this trend shows signs of weakening. Several major carriers who operate these aircraft, including Air France and Lufthansa are converting them to an all passenger configuration.[121] If this trend continues, the result may be additional emphasis on new freighter production.

Another change that will influence future aircraft purchases is the age of the cargo fleet. Worldwide, the average age of the commercial air cargo fleet is increasing. Presently, the cargo fleet averages over 22 years of age.[122] For example, approximately 353 Boeing 707-320C, McDonnell-Douglas DC-8-50, -60, and -70s are currently flying with commercial cargo carriers.[123] These aircraft have two characteristics that will facilitate their retirement or sale to third world nations. First, these airframes are nearing the end of their service life. Generally speaking, the older the equipment, the higher the

upkeep and operating costs. As a matter of economics, carriers will look to more efficient aircraft. The second factor is the mandatory Stage III noise regulations that take effect on December 31, 1999. Prior to the turn of the century, all aircraft operating in the United States must meet the stricter noise requirement. Again, as a matter of economics, carriers must determine if modifying aircraft to meet the Stage III requirements provides an adequate return on investment in the remaining life of the aircraft.

The number of aircraft out of Stage III compliance is significant. A 1994 Airbus Industrie study showed that "72% of the 1,048 freighters in service at the end of 1993 were Stage I and II aircraft that were more than 20 years old."[124] The combination of aircraft age and non-compliance with Stage III requirements could force the retirement or sale to foreign countries (with less restrictive noise regulations) of these aircraft. This would further open the market for new aircraft sales.

In sum, today's air cargo market may be capable of supporting the development of a civil-military transport. Overall market and niche growth, and the relative age of the commercial fleet combine to create conditions favorable to the development and market entry of a civil-military transport. However, general market growth does not mandate the development of a cargo transport with military characteristics. What facilitates the development and market entry of a civil-military transport is growth in the niche the transport will compete in. The outsize cargo market represents one market segment with potential. Presently, this niche favors a civil-military transport with outsize capability.

Aiding in the development of a civil-military transport that targets the outsize niche is the fact that the outsize market is immune to speculative changes in the commercial fleet. Commercial carriers cannot convert passenger aircraft to meet the outsize cargo

demand; the only avenue to procure outsize capability is purchasing new aircraft (or potentially purchasing surplus military transports). However, the outsize market may be time sensitive. If a civil-military transport is to take advantage of this expanding niche it should enter the market quickly. With foreign competition currently dominating this niche, the "window of opportunity" may begin to close if the foreign companies can improve the reliability of their products or introduce a new aircraft.

Changes in the Air Force

There are two major changes in the Air Force that may facilitate the development of a civil-military transport. First is the stability of the military fleet. For years, the airlift fleet has been in a constant state of shortfall. To eliminate the shortfalls, military transport procurement took precedence and little, if any, concern was given to the development of a civil-military transport. However, with the end of the Cold War, the sense of urgency that once surrounded past transport acquisitions has given way to a more pragmatic process. As a result, planners can look farther into the future when developing force structure. Second is a change in the Air Force acquisition process, namely, the precedent set by the C-17 Multi Year Procurement (MYP) contract. This method of contracting aircraft buys allows the aircraft manufacturer and the Air Force to more accurately plan production and procurement cycles.

The post Cold War era and our lack of a peer competitor has helped alleviate the sense of urgency that once surrounded the acquisition of new military transports. In past transport acquisitions, airlift shortfalls were dealt with as a matter of national security. As a result, the lack of emphasis on developing a civil-military transport may have been a

reflection of national priorities. For example, the Air Force is in the process of procuring 120 C-17s. The first aircraft was delivered in 1992 and the final delivery is contracted for 2003. The maximum number of aircraft programmed in a single year is 15 and averages 10.9 aircraft per year. The C-17 acquisition contrasts heavily with the C-141 purchase. The production run for the C-141 began in 1963 and finished in 1969. During the six year production run Lockheed built 285 aircraft. This averages over 47 aircraft per year. If the C-17 acquisition timeline becomes the standard, it will become easier for a manufacturer to program commercial variants in the normal production run.

The military fleet will remain relatively stable over the next ten to twenty years as procurements are timed to meet shortfalls created by retiring aircraft. For example, the Air Force timed the purchase of the C-17 to coincide with the retirement of the C-141. This scheduling will help mitigate major cargo shortfalls in the coming years and will minimize any pressure for an accelerated purchase of the C-17. The only potential change in the composition of the military airlift fleet will occur around the year 2000.[125] At this time, the Air Mobility Command (AMC) will decide whether or not to begin the retirement of the C-5A in 2007 or to pursue a service life extension program (SLEP). A SLEP of the C-5A appears more likely since the Air Force and Lockheed-Martin agree the airframe is structurally sound and only requires an update.[126] Furthermore, General Walter Kross, Commander in Chief, US Transportation Command, stated that a SLEP is the desired path.[127] When comparing the cost of purchasing additional C-17s or a new development, a SLEP appears the likely and prudent course of action.

Having a stable military fleet can aid in the development of a civil-military transport. However, the current fleet stability and the high probability of a C-5A SLEP tends to

eliminate the possibility of a new research and development project for a future civil-military transport. Given the current military fleet dynamics, it is extremely unlikely that the Air Force will embark on a costly development program (required for the next potential civil-military transport). This prospect is even more remote given the hard-won success of the C-17 program and the fact that a new airlift program would likely be an enhancement of current technology rather than a breakthrough that could revolutionize air cargo transport.

The decreasing numerical size of the military airlift fleet also speaks for the viability of a civil-military design. By 2006, the Air Force will have traded 265 C-141s for 120 C-17s. While the C-17 is a more capable aircraft, the loss of 145 airframes will limit the number of operations that AMC will be able to commit too over a given period of time. In order to maintain the same level of service, the Air Force must to turn to the commercial sector. Missions that require the capabilities of a military airlifter may go unfilled if a suitable commercial aircraft is unavailable. Two prime examples are humanitarian operations and disaster relief. Both missions often require aircraft that can operate in an austere environment with minimal infrastructure. These situations require aircraft with military transport characteristics; however, they do not require a military crew. If the present pace of these operations continue, it could favor the fielding of a civil-military transport with capabilities appropriate for these missions. It is important to note that military contracts alone will not insure the success of a civil-military transport. As the model in Chapter Two showed (see figure 8), military contracts are only a small portion of what is needed to make a civil-military transport viable; however, these

additional contracts can provide a significant monetary supplement to a commercial operation.

Acquisition reform may hold a major key to the development of future civil-military aircraft. Past aircraft buys negotiated a fixed price that was re-negotiated annually. However, with the purchase of the C-17 the Air Force and McDonnell Douglas established a new and innovative acquisition tool--the Joint Cost Model. The new model greatly streamelined the negioation process and facilitated a fixed price buy on the remaining 80 C-17s over the life of the MYP contract.[128] The negotiated price is approximately $180 million per C-17 over the 10-year period of the contract.[129]

The MYP contract is unique for another reasons. The contract contains a Foreign Military Sales (FMS) and Direct Commercial Sales (DCS) clause.[130] This clause allows the Air Force and McDonnell Douglas to pursue FMS/DCS sales of the C-17 while fulfilling the Air Force contract. The FMS/DCS sales clause protects the Air Force and also benefits McDonnell Douglas. The Air Force initiated the clause as a means of protecting the contracted price. For example, the Air Force will procure a maximum of fifteen C-17s in any given year. However, if Congress funds only thirteen C-17s in a given fiscal year the Air Force has the ability to "substitute" FMS or DCS sales of the C-17 in the two unfunded production slots. This assumes that the Air Force and McDonnell Douglas has cultivated enough FMS/DCS sales to fill the slots. In return, the Air Force will retain the lower cost for the thirteen aircraft produced in that year.

Summary

Many of the factors that inhibited the development of previous civil-military transports have changed. This presents the opportunity for the development and market entry of a new civil-military transport. While the growing air cargo market and the rapidly expanding outsize cargo niche appear to reduce the risk of owning an aircraft with military characteristics, they are not a guarantee of success. However, by combining market growth with a shrewd marketing plan that develops or undercuts the cost of operating in a particular market niche, the chances of success significantly improve.

Additionally, the military context has also changed and supports the development of a civil-military transport. The stability of the military fleet has reduced the sense of urgency that once surrounded the procurement of new transport systems. Furthermore, it appears the military fleet will remain relatively stable for the next twenty to thirty years. While this rules out the development of a new transport, it supports McDonnell Douglas's bid to market the MD-17. Probably the most important change in the military sector is in the acquisition arena. The FMS/DCS sales clause of the C-17 MYP contract acknowledged the importance of non-U.S. military sales of the C-17 to the aircraft's manufacturer and the Air Force. Potentially, this clause can be expanded to facilitate development of a civil-military transport if commercial variants are viewed in a similar light. In sum, current conditions and trends in acquisition reform are favorable to and may facilitate the development and market entry of a civil-military transport.

Notes

[13].See recommendation number 1 (1) under "Summary of Subcommittee's Recommendations." US House, *Report of Special Subcommittee on National Military Airlift of the Committee on Armed Services,* 86th Cong., 2d Sess., 1960,), 4051. Hereinafter referred to as *The 1960 National Military Airlift Report.*

Notes

[14].Frederick C. Thayer, *Air Transport Policy and National Security, A Political, Economic, and Military Analysis,* (Chapel Hill, N.C.: North Carolina Press, 1965), 223.

[15].Ibid.

[16].Ibid.

[17].*The 1960 National Military Airlift Report,* 4051.

[18].Ibid., 4048.

[19].Ibid., 4035.

[20].US Department of State, *Department of State Bulletin* no. 44 (Washington D.C.: Government Printing Office, 13 February 1961), 211.

[21].Military Airlift Command, *The C-141 Starlifter* 1, MACH-36, (Scott AFB, Ill.: HQ MAC, n.d.), 21.

[22]. There are six classifications for air carriers according to the FAA. For the purposes of this thesis only two are discussed. They are scheduled and nonscheduled carriers. The FAA defines the scheduled air carriers as, "Certificated air carrier - An air carrier holding a Certificate of Public Conveyance and Necessity issued by DOT to conduct scheduled services interstate. These carriers may also conduct Nonscheduled or charter operations. These carriers operate large aircraft (30 seats or more or a maximum payload capacity of 7,500 pounds or more) in accordance with FAR Part 121." Nonscheduled carriers are defined as, "Supplemental air carriers (Charter) - An air carrier which holds Certificates of Public Convenience and Necessity issued by DOT, authorizing performance of passenger and cargo interstate charter services supplementing the scheduled service of the Certificated carriers. The authority of supplemental air carriers to engage in military charters is of an indefinite period. In addition, they can perform on an emergency basis, as may be authorized by the DOT, scheduled operations including the transportation of individually ticked passengers and individually way-billed cargo." See *FAA Statistical Handbook of Aviation, Calendar Year 1989,* (Washington D.C.: Government Printing Office, 1989), G-1. Each of these definitions is similar to the definition used in the early 1960s. For earlier definitions see *FAA Statistical Handbook of Aviation 1962 Edition,* (Washington D.C.: Government Printing Office, 1962), 139 and 144.

[23]."Joint Civil-Military Planning--The Lockheed C-141 Jet Freighter," *Interavia* 17, January 1962, 87.

[24].Thayer, 131-232.

[25].The term "large" referred to the ability of the aircraft to handle oversize and heavy cargo. At the time bulk cargo comprised the market. In this respect the carriers needed a larger aircraft; however, it was capacity they were concerned with, not oversize capability. Ibid., 232.

[26]."Air Transportation Trends," *Airlift World Air Transportation* 26, no. 10, March 1963, 13.

[27].Lockheed was unable to sell a single L-300; however, the test bed C-141A used for the FAA certification process was sold to the National Air and Space Agency in 1973.

[28]."Air Transportation Trends," 13.

[29].Ibid.

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[30].“Lockheed’s Big Jet Freighters--The L-300 and L-300B,” *Interavia* 19, October 1964, 1496.

[31].Ibid.

[32].Ibid.

[33].Ibid.

[34].Ibid., 1495.

[35].Ibid.

[36].Thayer, 232. Source: US Senate, *Department of Defense Appropriations for 1963, Hearings Before Subcommittee*, 87th Cong., 2nd Sess., 1383.

[37].Thayer, 232. See footnote 12.

[38].“Airlift, Military's Number 1 Budget Cut,” *Airlift World Air Transportation* 26, no. 10, March 1963, 25.

[39].Thayer, 264. See footnote 112.

[40].“Airlift, Military's Number 1 Budget Cut,” 25.

[41].The CL-44 was known as the “Swing-tail.” The empennage of the aircraft was hinged allowing it to swing 90 degrees out of the way. This allowed “straight-in” loading.

[42].Selig Altschul. “Why The Stretch in Jet Depreciation,” *Airlift World Air Transportation* 26, no. 9, February 1963, 35.

[43].US House, *Hearings Before the Special Subcommittee on National Military Airlift, Committee on Armed Services*, 88th Cong., 1st Sess., 5987.

[44].Ibid.

[45].Ibid.

[46].Ibid., 5988.

[47].Julius Alexander, Lockheed-Martin Public Relations, Interviewed by author, 18 March 1997.

48.Ibid.

49.Wallace I. Longstreth, “Cargo Climbs 20% in 1962...Equipment Interest Shifts to Jets,” *Air Cargo*, May 1963, 43.

[50].“Lockheed Super Hercules,” Promotional brochure printed by the Lockheed Aircraft Corporation, Georgia Division, Marietta, Ga. GELAC-MSHB-AF-5901.

[51].These variants are were all developed for the United States. The author was unable to determine to total number of worldwide variants that Lockheed has developed. See M. E. Morris, *C-130, The Hercules* (Novato Calif.: Presidion Press, 1989), 101.

[52].Ibid., 83.

[53].Ibid., 84-85.

[54].Ibid., 77.

[55].“Lockheed Super Hercules,” 15.

[56].Ibid.

[57].Ibid.

[58].Ibid.

[59].The Super Hercules was a “growth version” of the C-130. Over 65% of the aircraft tooling for the GL-207 was the same as the C-130. The major difference

between the two aircraft was a longer cargo compartment and more powerful engines. See "Lockheed Super Hercules," 11-12.

[60].Lockheed also initiated research into a turbojet version of the GL-207. This design would eventually evolve into the GL-207-45, better known as the C-141 *Starlifter*. This version was never marketed in the 1950s. See Military Airlift Command, *The C-141 Starlifter* 1, MACH-36, (Scott AFB, Ill.: HQ MAC), 21.

[61].Francis K. Mason, *Lockheed Hercules* (Wellingborough England: Patrick Stephens Limited, 1984), 172.

[62].Ibid.

[63].Ibid.

[64].Morris, 109.

[65].Mason, 151.

[66].This airframe was the same as the C-130Es currently in production for the Air Force. See Mason, 151.

[67].Joseph E. Dabney, *Herk: Hero of the Skies* (Lamonte, Ga.: Copple House Books, Inc., 1986), 415.

[68].Dabney, 239.

[69].Mason, 151.

[70].Ibid.

[71].Ibid.

[72].Ibid., 155.

[73].Ibid.

[74].Ibid., 164.

[75].Ibid.

[76].The sole remaining L-100 is in possession of the Pakistani Air Force. See Paul Jackson, ed., *Jane's All The World's Aircraft, 1996-1997* (London: Butler and Tanner Limited, 1996), 639.

[77].Ibid.

[78].These versions include the C-130H-30 operated by the USAF and the C.MK3 operated by the RAF. See Morris, 129.

[79].Chuck Grieve, "Freighter Fleet To Double By 2015," *Payload Asia,* November 1996, 15.

[80]."McDonnell Douglas Studying Future For Commercial MD-17," *Aviation Daily,* 1 April 1997, 5.

[81].McDonnell Douglas Corporation, *C-17 Globemaster III, Pocket Guide* (Long Beach Calif.: McDonnell Douglas Corp., 1996), 21.

[82]."The C-17: From Trouble to Triumph. The Airlifter Begins to Overcome Its Difficult Legacy," *Armed Forces Journal International,* September 1995, 35.

[83].Bruce C. Smith. "Few Orders Required to Launch MD-17." *Aviation Week & Space Technology* 145, no. 16, 14 October 1996, 39.

[84].David A. Fulghum and Bruce C. Smith. "Pentagon Plans Aggressive C-17 Buy." *Aviation Week & Space Technology* 43, no. 20, 13 November 1995, 21.

[85] .According to the Multi Year Procurement contract signed by the Air Force and McDonnell Douglas the production schedule for the C-17 is as follows:

Fiscal Year	1997	1998	1999	2000	2001	2002	2003
Procurement	8	9	13	15	15	15	5

This timetable shows that only in years 2000, 2001, and 2002 will the Air Force use 100% of the current C-17 production capacity. See *Military Airlift: Options Exist for Meeting Requirements While Acquiring Fewer C-17s*, GAO/NSIAD-97-38, Washington D.C.: Government Printing Office, February 1997, 14-15.

86.It is important to clarify the distinction between Foreign Military Sales (FMS), Direct Commercial Sales (DCS), and commercial sales. FMS and DCS involve the marketing and sale of the C-17. FMS sales require government-to-government negotiations and sales; whereas, DCS sales are contractor-to-government sales of the military version. Commercial sales on the other hand denote contractor-to-commercial customer sales of the MD-17 only.

[87].Smith, 21.

[88]. Maj Tim Cook, Director C-17 Program, AFPEO/AT, Interviewed by author, 27 March 1997.

[89]."McDonnell Douglas CEO Says Company Will Pursue MD-17," *Inside The Air Force*, 13 September 1996, 10.

[90].Web Heath, Manager, Technical Liaison with FAA, McDonnell Douglas Corporation, Interviewed by author, 31 March 1997.

[91].Bruce C. Smith "Few Orders Required To Launch MD-17," *Aviation Week & Space Technology* 145, no. 16, 14 October 1996, 40.

[92] Heath Interview.

[93].Ibid.

[94].Sandra I. Meadows, "Military Cargo Heavyweight Poised To Succeed In Commercial Shipping," *National Defense*, January 1997, 24.

[95] McDonnell Douglas Corporation, Promotional Brochure GP 960140 2-97, February 1997, 14.

[96].Ibid.

[97].Ibid.

[98].*Selections From The MD-17 Business Plan*, GP-970137 3-97 (Long Beach Calif.: McDonnell Douglas Corporation, 1997), 4-9. Hereinafter referred to as the *MDC Business Plan*.

[99].Ibid. 3-3.

[100].Ibid.

[101].Ibid., 3-12.

[102].Mike Rohrlick, Program Manager, Advanced Airlift Systems, McDonnell Douglas Corporation, Interviewed by author, 18 March 1997.

[103].Ibid.

104."MD-17 To Cater For Heavy Outsize Freight," *Payload Asia*, November 1996, 14. As a comparison, the An-124 operates at a rate of $14,000 to $15,000 per block hour. See Michael Taverna and Yann Cochennec, "Ruslan Opening the Door for CIS Cargo, Airlines," *Interavia*, January 1995, 33.

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[105].Rohrlick Interview.

[106].*MDC Business Plan*, 3-9.

[107].Department of the Air Force, *Global Engagement: A Vision for the 21st Century Air Force* (1996): n.p.; on-line, Internet source 25 November 1996, available from http://www.af-future.hq.af.mil/21/logi/.hmtl.

[108].Robert F. Caton, President, Cargo Shipping Transportation Analyst, Email with author, 24 February 1997.

[109].Robert V. Dahl, "Air Freight Market Is Expanding," *Aviation Week & Space Technology* 146, no. 2, 13 January 1997, 51.

[110].Ibid.

[111].Ibid., 52.

[112].The 500% figure reflects the initial growth of a market that prior to 1989 was non-existent. When the first outsize capable aircraft entered the commercial sector, there was a rush to take advantage of their capabilities. This combined with the fact that the new market started at zero, accelerated the growth curve. See James R. Asker, ed., "Washington Outlook," *Aviation Week & Space Technology* 143, no. 9, 13 November, 1995, 19. Today, McDonnell Douglas estimates that since 1989 the outsize market has averaged 55% expansion per year since 1989. See McDonnell Douglas Corporation, *MD-17 Promotional Brochure*, GP 960140 2-97, February 1997, 3. Hereinafter referred to as *MD-17 Brochure*.

[113].*MD-17 Brochure*, 3. Additionally, a figure of 12.5% per year is cited by AIRTRANS, Inc., a air cargo industry analytical service firm. See *Selections From The MD-17 Business Plan*. GP-970137 3-97. Long Beach Calif.: McDonnell Douglas Corporation, March 1997, 3-4.

[114].Boeing Aerospace estimates the current fleet at 1,219. They define a large cargo aircraft as over 50 tons. McDonnell-Douglas estimates the current fleet at 1,287 aircraft. See Chuck Grieve, "Freighter Fleet To Double By 2015," *Payload Asia*, November 1996, 15.

[115].The McDonnell Douglas figure is based on a date of 2014 vice 2015 for the Boeing prediction. See Grieve, 15.

[116].Ibid.

[117].The definition of 'large" has no industry standard and varies depending upon who you talk too. For example, Boeing defines a large cargo aircraft as one with a capacity over 50 tons. Whereas, McDonnell-Douglas defines a large aircraft as one over a 77 ton capacity. See Grieve, 15. Additionally, the Air Cargo Management Group, an independent air cargo consulting service pinpoints the jet fleet at 1,257. See Robert V. Dahl, "Air Freight Market Is Expanding," *Aviation Week & Space Technology* 146, no. 2, 13 January 1997, 51-52.

[118].Grieve, 15.

[119].Ibid.

[120].Ibid.

[121].Ibid.

[122].Ibid.

[123].Dahl, 52.

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[124].Paul Constance, “Cargo Customers Demanding More,” *Aviation Week & Space Technology* 142, no. 11, 13 March 1995, 76-77.

125.David A. Fulghum, and Bruce A. Smith. “Pentagon Plans 'Aggressive' C-17 Buy.” *Aviation Week & Space Technology* 43, no. 20, 13 November 1995, 21.

[126].Jeffrey Record, “After the C-17: Coming Airlift Realities and Choices,” *Armed Forces Journal International*, December 1996, 33.

[127].John A. Tirpak, “The New Boss at Air Mobility Command,” *Air Force Magazine*, March 1997, 39.

[128].Department of the Air Force, “Acquisition Reform Success Story, ” n.p.; on-line, Internet source 2 April 1997, available from http://www.safaq.hq.af.mil/acq_ref/stories/c17_1.html. Hereinafter referred to as “Acquisition Reform.”

[129].According to the *Program Status Summary Report*, published January 31, 1997, the average cost over the period of the contract is $180 million per unit. The $180 million figure is based on FY96 buy year dollars for the average unit flyaway cost for the remaining aircraft. However, the actual price is subject to change depending upon the number of aircraft enhancements added over the remaining years of the contract. Maj Tim Cook, Director C-17 Program, AFPEO/AT, Interviewed by author, 27 March 1997.

[130].“Acquisition Reform.”

Chapter 5

Summary and Recommendations

America's military might is dependent upon rapid global mobility. To meet this need, the National Airlift Fleet (NAF) maintains the required capacity and capabilities necessary to project force as national policy dictates. One way of strengthening the NAF is with the procurement of civil-military transports by the commercial sector. A civil-military transport based on a military design can enhance mobility and foreign policy, and result in more efficient operations when the military and commercial sectors interface. To this end, this thesis examined several attempts to place a civil-military transport in service in the commercial sector with the goal of identifying what factors influenced the developmental process. Furthermore, this study sought to determine if current conditions are conducive to the fielding of a contemporary or future civil-military transport.

In the course of this study, economics emerged as the most critical factor in the development of a civil-military transport. Most important, is the niche market targeted for the civil-military transport and the timing of the aircraft's entry into the commercial sector. This study revealed that in order for a civil-military transport to succeed, it should initially target a niche that exploits its technology. Ideally, the niche market should be new and/or in a rapid growth period as the manufacturer markets the aircraft. New markets are ideal because a civil-military transport has the competitive edge over aircraft

that are not optimized for the requirement. Having an aircraft available in a rapidly growing market provides air carriers with additional purchasing options. Thus, carriers may choose to purchase them in order to rapidly field the aircraft and capture market share in the targeted niche. However, placing a civil-military transport in a specific new or small niche market does not mean that it will remain solely in that market. As the L-100 proved, "a foot in the door" of a niche market can lead to an expanded role in the commercial sector.

Creating or finding a niche market that is expanding may not always be possible. If the aircraft enters a currently established niche, the civil-military transport must undercut the competing aircraft by offering a significant economic advantage to the aircraft's operators. If unable to offer a significant economic incentive, marketing the aircraft is an up-hill battle and serious consideration should be given to terminating the civil-military project.

A second economic factor that can inhibit commercial acceptance of a civil-military transport is the high cost of the aircraft. Each of the aircraft analyzed carried large price tags and in each case, the high initial cost influenced potential buyers. To circumvent this problem, Lockheed assumed some of the risk by leasing the first L-100. This strategy facilitated placing the aircraft in the commercial sector and allowed it to prove its commercial viability. This led to additional leases and sales.

The third critical economic factor that emerged is the importance of the military production run. In all three case studies, when a military sponsored project was canceled, the T61 turboprop engine, put on hold, like the C-17 probation, or never initiated, like the L-300B, the effort to produce commercial version of the aircraft failed to advance, even

when there was commercial interest in the aircraft, as in the L-300B. This factor highlights the importance of the military maintaining a close watch on the civil-military potential of each developmental aircraft.

This study also revealed that technological differences between commercial aircraft and military transports do not inhibit the success of a civil-military transport, that is unless the aircraft targets a niche where its technology is too inefficient to operate. Each of the civil-military transports studied (or versions) had commercial interest in the airframe. In reality, their failure to enter service is due to other factors such as high initial cost, the lack of a military production run, a canceled developmental contract, or threatened cancellation of the project. In any event, the historical evidence suggests that technology differences are not a major factor in the commercial sector's willingness to operate the aircraft.

Politics, on the other hand, emerges as a major factor in the development of a civil-military transport only when governmental interest remains constant. The L-300 is an excellent case in point. Initial government interest in the project was extremely strong; however, within several years the enthusiasm had faded. As government interest in the project waned, so did the push for the joint developmental process (see figure 1 in Chapter One), and as a result, only the military version went into production. However, despite inconsistent government interest in the L-300, the government appears to have done little to inhibit the aircraft's development. If anything, it served to focus the commercial sector's attention on the economic viability of the aircraft, and not the chance of government secured loans, subsidies, and guaranteed contracts. As for the L-100 and the MD-17, governmental interaction was and is limited to Federal Aviation

Administration (FAA) certification procedures and removal from the State Department's controlled munitions list. Both of these actions are concerns of the aircraft manufacturer and not potential buyers. Therefore, the commercial sector's focus is also on the aircraft's economic viability.

Recommendations

This study has shown that today's environment is favorable for the development and market entry of a civil-military transport. In the commercial sector, the combination of projected long-term market and niche growth, predicted freighter production, and changes in the cargo fleet dynamics are favorable to the development and production of a civil-military transport. Additionally, conditions in the military sector are favorable to civil-military transport development. The stability of the airlift fleet, the projected lack of major force structure changes in the next twenty to thirty years, and changes in the acquisition process improve the conditions needed for the fielding of a civil-military transport.

Given the current positive environment and the obvious military benefits of civil-military transport, it is in the Air Force's interest to facilitate their entry into the commercial sector. To this end, the following recommendations may improve the chances of success.

Support the development of a commercial variant. To date, the Air Force has not actively supported the development of any civil-military transport. In fact, it appears that every effort has been made not to give the appearance of providing a competitive advantage to a specific aircraft manufacturer or air carrier. However, as reliance on the

commercial sector increases, it may be time to shed the paradigm that has limited Air Force support for past commercial variants. Therefore, it is in our national interest to support the fielding of any aircraft that enhances mobility operations. This will require advocating civil-military transports in the same way that the Air Force advocates Foreign Military Sales (FMS) and Direct Commercial Sales (DCS).

Examine each military transport development process and determine the viability of a commercial variant. As a part of the developmental calculus, the Air Force should scrutinize each new military transport design for commercial potential. By working closely with the aircraft makers and potential buyers, the Air Force can help facilitate the development of the commercial variant if its success appears probable.

Develop incentives that target civil-military transports. Over the years the Air Force has offered numerous incentives and subsidies to commercial carriers to entice participation in CRAF. These incentives and subsidies have, in general, served their purpose; however, they have not helped bridge the technological gap between commercial and military aircraft. This study recommends that the Air Force consider developing an incentive package that specifically targets potential civil-military transport operators that are CRAF participants. This will help ease the financial burden of purchasing and operating a civil-military transport. However, it is imperative that incentives not be used to subsidize a civil-military transport that is economically incapable of operating at a profit in the commercial sector.

Expand the FMS/DCS sales clause of the Multi Year Procurement contract. The Air Force originally proposed this clause as a means of protecting the unit price of the C-17. However, consideration should be given to expanding the clause to encompass

commercial variants. This will help facilitate and protect the commercial viability of the aircraft. Treating the sales of commercial variants in the same way FMS/DCS sales are treated would allow the "substituting" of commercial variants in unfunded production slots. This could benefit the Air Force in two ways. First, it may decrease the unit cost of the military version. Second, it helps the manufacturer establish the aircraft in the commercial sector. This, in turn, benefits the Air Force by increasing the capability of commercial sector.

Coordinate with the Federal Aviation Administration and the State Department early in the developmental process. These two government organizations have tremendous influence on the eventual release for sale of commercial variants. From the beginning of the developmental process, every effort should be made by the Air Force to facilitate the FAA certification of a commercial variant and release of the aircraft from the State Department's controlled munitions list. Being proactive will decrease the amount of time required to develop and field a civil-military transport. This can be critical if the niche market targeted by the commercial variant is time sensitive.

Monitor the commercial industry for change. Civil-military transport programs, like any other large aircraft projects, are sensitive to changes in the airline environment. The Air Force must monitor these changes to ensure that a civil-military transport "window of opportunity" is not missed or that valuable resources are not squandered trying to force a civil-military transport into the commercial sector when it is not viable.

Conclusion

This study has shown that the civil-military transport concept remains viable. In fact, it has shown that the current environment favors the fielding of a contemporary aircraft, and therefore, should be pursued. While civil-military transports are not the only answer to airlift shortfalls, they can be a part of the solution. Therefore, it is incumbent upon the Air Force to make every effort to make the concept a reality, rather than remaining a bystander.

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